INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION

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DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled "**INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION**" submitted towards partial fulfillment of the requirements for the award of **MD IN ANAESTHESIOLOGY** degree to BFUHS is a compilation of original work carried out by me under the supervision of **Dr. SUNEET KANT KATHURIA**, Professor, Department of Anaesthesiology, **Dr. UDEYANA SINGH**, Associate Professor, Department of Anaesthesiology. No part of this thesis has formed the basis for the award of any degree previously.

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ABBREVATIONS

ASA	Americam Society Of Anaesthesia
CAD	Coronary Artery Disease
CAPVV	Carotid Artery Peak Systolic Velocity Variation
CIMT	Carotid Intima-Media Thickness
CVP	Central Venous Pressure Monitoring
DBP	Diastolic Blood Pressure
DM	Diabetes Mellitus
HR	Baseline Heart Rate Of The Patient
HTN	Hypertension
IJVCI	Internal Jugular Vein Collapsibility Index
IVCCI	Inferior Vena Cava Collapsibility Index
JVP	Jugular Venous Pressure Measurement
MBP	Mean Blood Pressure
PA	Pulmonary Artery
PI	Perfusion Index
PLR	Passive Leg Raise Test
PSAH	Post Spinal Anaesthesia Hypotension
SBP	Systolic Blod Pressure
SVR	Systemic Vascular Resistance
TEE	Transthoracic Echocardiography

ABSTRACT

Introduction: Inferior vena cava and internal jugular vein collapsibility index are being increasingly used as noninvasive tools to predict hypovolemia in emergency and critical care settings. Hypotension is a common intra operative complication post spinal anaesthesia, as a result of sympathetic blockade. Successful prediction of post spinal hypotension can help in adoption of appropriate preventive and treatment measures to minimise perioperative morbidity.

Aim of the Study: Comparison of inferior vena cava and internal jugular vein collapsibility index for prediction of post spinal hypotension.

Materials and methods: A prospective, cross sectional, observational study was conducted on 50 adult patients of ASA I, II and III scheduled to undergo elective surgery under spinal anaesthesia. The inferior vena cava collapsibility index and internal jugular vein collapsibility index were assessed as a tool for prediction of post spinal hypotension. After giving spinal anaesthesia using a standard protocol, monitoring of heart rate, systolic, diastolic and mean blood pressure was done upto 30 minutes to compare incidence and severity of hypotension.

Result: IVC collapsibility index (IVCCI) at a cutoff value of 43%, had a sensitivity and specificity of 42.86% and 74.42% respectively, in prediction of post spinal anaesthesia hypotension (PSAH). For IJV collapsibility index (IJVCI) at 0º, a cut off value of 39% had sensitivity and specificity of 28.57% and 83.72% respectively, and IJVCI at 30º head elevation at same cut off value of 39% had sensitivity and specificity of 28.57% and 58.14% respectively. All the results for IVCCI and IJVCI (0º and 30º) were statistically insignificant. However, IVCCI cutoff value of 33% predicted PSAH with sensitivity and specificity of 100% and 62.79% (p value = 0.002).

Conclusion: We concluded that, the pre-operative inferior vena cava collapsibility index (IVCCI), can be helpful in predicting patients at the risk of post spinal hypotension. Meanwhile, IJVCI can be used as a helpful parameter in critically ill patients only.

Keywords: inferior vena cava, internal jugular vein, collapsibility index, spinal anaesthesia, hypotension

Dedicated
to
My
Maternal
Grandmother,
Family,
&
Teachers

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INTRODUCTION

Spinal anaesthesia is frequently used in anaesthesia practice. Spinal anesthesia is a safe and reliable technique used in various lower abdominal, orthopedic, and obstetric operations. It has advantages such as the rapid onset of action, cost-effectiveness, ease of administration, and relatively fewer side effects.

The common side effects of sub arachnoid block are bradycardia and hypotension. Incidence of post spinal anaesthesia hypotension (PSAH) is about 15-33 % which, if severe and untreated can result in organ hypo perfusion and ischaemic events [1]. PSAH may be associated with nausea, vomiting, syncope, dizziness, aspiration, cardiac arrhythmias, cardiac arrest, and even death. Intraoperative hypotension has been found to correlate with post-operative morbidity and mortality [2, 3]. Therefore, predicting PSAH is particularly important so that preventive measures or timely interventions can be taken to avoid any untoward events.

Main reasons for decrease in systolic blood pressure are decrease in systemic vascular resistance and cardiac output [4]. Patients' susceptibility to intraoperative hypotension can also be influenced by the preoperative volume status, associated comorbidities, physical status, pre-operative medications and fasting [5].

Prediction of hypotension and adoption of appropriate preventive measures like optimization of fluid status and early institution of appropriate treatment helps to reduce morbidity and risk of serious complications like stroke, heart and kidney failure, prolonged hospitalisation and postoperative mortality [6]. Many techniques have been tried to prevent post spinal hypotension, such as intravenous volume preload, co-load or use of prophylactic vasopressors [7, 8]. The prevention of PSAH via intravenous (IV) fluid loading is a relatively older method. Fluid boluses fail to adequately increase heart volume in about 50% of individuals with haemodynamically unstable conditions. In a patient who is not responsive to fluids, empirical fluid loading has little to no effect and

may possibly impair the patient's fate. Differentiating the cohort of patients needing fluid boluses from vasopressors remains a challenge because there is no reliable method to predict spinal hypotension [9].

Moreover, empirical volume loading carries the potential of volume overload, particularly in patients with pre-existing cardiac disease. The successful prediction of hypotension is necessary to guide appropriate volume loading to prevent post spinal hypotension [10].

Various invasive and non-invasive methods are employed to check the fluid status and hypotension vulnerability in critically ill patients like:

- Baseline heart rate of the patient (HR)
- Jugular venous pressure measurement (JVP)
- Central venous pressure monitoring (CVP)
- Inferior vena cava collapsibility index (IVC-CI)
- Internal jugular vein collapsibility index (IJV-CI)
- Perfusion index (PI)
- Passive leg raise (PLR) test
- Transthoracic echocardiography (TTE), transthoracic bioimpedance
- Carotid artery peak systolic velocity variation (CAPVV)
- Carotid intima-media thickness (CIMT)
- Pulmonary artery (PA) catheter

The role of clinical examination in assessing the intravascular volume status of patients has been found to be unreliable and lacks accuracy and precision [11, 12]. Studies have been done on baseline heart rate, heart rate variability as a predictive parameter of hypotension [13]. As the higher heart rate reflects higher sympathetic activity and thus, will result in more hypotension after spinal sympathetic blockade [14, 15]. Measuring central venous pressure (CVP) by inserting a central venous catheter was though a gold standard technique, but it is invasive, time-consuming and associated with complications [16, 17]. Height of external jugular venous pulsation when used as indirect measure of CVP has a poor sensitivity [18].

The non-invasive methods like perfusion index using Masimo pulse oximeter, inferior vena cava (IVC) diameter, collapsibility or caval index, IJV diameter, IJV collapsibility index using ultrasonography etc. have been used as alternate approach to invasive CVP measurement, but with varying results. Perfusion index [PI] is a relatively newer, simple and cost effective method of assessing peripheral perfusion [19]. It is calculated as the ratio between the amplitude of the pulsatile component (arterial compartment) to non-pulsatile component (venous and capillary blood, and other tissues) of the light reaching the detector of the pulse oxi-meter. But, PI is totally oximeter based parameter and value of perfusion index can be variable due to incorrect sensor placement and motion artifacts [20]. PI is commonly affected by factors such as movement, temperature, psychological stress and anxiety, which can induce sympathetic activation. It is difficult to control these factors in awake patients [21].

Various other non-invasive modalities, like transthoracic echocardiography (TTE), transthoracic bio-impedance, passive leg raising test (PLRT) etc. have been used to predict PSAH in different sub-groups including the obstetric patients, revealing varied results [22]. However, TTE is time-consuming and needs significant operator training and efficiency. Bio-impedance derived CO measurement is costly and not readily available [9].

A study on carotid intima media thickness (CIMT) by Kaydu A et al. concluded a threshold value of CIMT of 0.65 mm that may be used as a predictor of hypotension after the induction of general anaesthesia [23].

Pulmonary arterial catheter is another technique that has been described to assess preload among other elements of haemodynamic status. However, its universal use remains debatable due to financial restrictions, relatively high complication rates, and invasiveness.

Nowadays, point of care ultrasonography is getting more importance in patient management, especially in emergency and ICUs due to fewer complications. Complications associated with central venous pressure

(CVP) insertion include pneumothorax, bleeding and arterial punctures, risk of local and distant infections, such as insertion site infections and catheter-related bloodstream infections, and septic emboli [17].

Ultrasonographic assessment of carotid artery peak systolic velocity variation (CAPVV) is a newer approach and is easy to perform, non-invasive, time-efficient, and readily available as well [9, 24, 25].

Many studies have identified sonographic determination of inferior vena cava (IVC) collapsibility index (IVCCI) as non-invasive and easy technique for evaluating volume status [5, 9, 10, 26, 27]. Recent guidelines from the American Society of Echocardiography support the general use of IVCCI in assessing volume status. The inferior vena cava (IVC) is a compliant vessel whose size and shape varies with changes in CVP and intravascular volume [28]. Therefore, sonographic measurement of variation in IVC diameter with respiration and IVC collapsibility index represent an effective and non-invasive method of estimating fluid status [29].

IVC Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

Zhang et al found the cut off value of IVC collapsibility index to be 43% while predicting hypotension in general anaesthesia [5]. A few other sonographic parameters like caval aorta index (IVC diameter: aortic diameter) and dIVCmax (maximum diameter of IVC at expiration): IVCCI ratios have also been evaluated as predictors of PSAH. The pre-operative caval aorta index was found to be a better predictor of PSH (sensitivity 96%) than IVCCI (sensitivity 84%) in elderly patients [10]. Saranteas *et al*. found that dIVCmax: IVCCI predicted PSAH better than IVCCI >0.3 (P = 0.032). This measurement takes both static (dIVCmax) and dynamic (IVCCI) components into account [30].

In 10%–15% of patients, IVC measurement is difficult /not possible due to obesity, surgical dressings and drains, excessive intra-abdominal gas,

extrinsic structures compressing IVC, increased intra-abdominal pressure, increased pulmonary artery pressure, tricuspid, or pulmonary valvular disease etc. Furthermore, it is important to note that changes in the intra-thoracic pressure and breathing pattern significantly affect the IVC diameter in a spontaneously breathing patient [29, 31, 32].

Many parameters of the internal jugular vein (IJV) are being increasingly used as an alternative to IVC measurements, to indirectly measure the fluid status. Few studies are available on the IJV diameter, cross-sectional area, and collapsibility index (CI) by ultrasonography as a measure of fluid status of critically ill patients [6, 33]. Anterior-posterior [AP] diameter of internal jugular vein between 5.7 - 8.3 mm, roughly corresponds to CVP of < 10 cm of H_2O and its values between 11.2 - 13.8 mm, correspond to CVP > 10 cm of H_2O [34]. Collapsibility index [CI] of internal jugular vein can be derived from AP diameter and is defined as under**:**

IJV Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

In intensive care unit, Kilu et al found that patients with IJV diameter collapsibility index > 39% are considered to be more prone to hypotension [33]. Moreover, Halilo˘glu et al. reported that IJVCI more than 36% had sensitivity and specificity of 78% and 85% respectively, in predicting hypovolemia [35]. So, ultrasound guided IJV collapsibility index can provide an extra edge in clinical scenarios where IVC is difficult to visualise.

Most of the studies on prediction of hypotension have been done in ICU patients using IVC collapsibility measurements, but only a limited number of studies are available for prediction of hypotension in spinal anaesthesia till date. In this prospective, cross sectional, observational study, we compared the ability of inferior vena cava collapsibility index and internal jugular vein collapsibility index in effectively predicting hypotension after spinal anaesthesia.

AIMS AND OBJECTIVES

To compare efficacy of Inferior vena cava collapsibility index and internal jugular vein collapsibility index in prediction of hypotension after spinal anaesthesia.

REVIEW OF LITERATURE

Thoraco-lumbar sympathectomy is the root cause of hypotension after spinal anaesthesia. The reduction in both cardiac output and systemic vascular resistance (SVR) contributes significantly to spinal anaesthesia-induced hypotension. Due to pooling of blood in lower extremities of the body, the preload decreases, thereby compromising the cardiac output and blood perfusion of vital organs. Both baseline volume status and baseline vascular tone have influence over the degree of hypotension after spinal anaesthesia [4]. Hypovolemic patients are more susceptible to post spinal hypotension.

The physiology of spinal-anaesthesia-induced hypotension seems to be different in elderly population as compared to younger patients. At T4-T6 sensory levels of spinal anaesthesia, SVR decreases by 23-26%, central venous pressure by 2-3 mm Hg, and left ventricular end diastolic volume by 20%. The higher degree of resting sympathetic tone exhibited by elderly patients may explain the marked decrease in SVR to sympathetic blockade compared with younger patients [22].

Hypotension along with bradycardia may lead to several adverse outcomes including coronary ischaemia and delirium. It is necessary to identify readily available variables to help anesthesiologists recognize patients with modifiable risk factors. The assessment of the intravascular volume status is challenging for the clinicians. Different invasive and non-invasive techniques have been tried in intensive care units and operating rooms to evaluate the volume status of the patient. The invasive methods include central venous pressure monitoring and pulmonary artery catheter insertion whereas non-invasive methods are baseline heart rate, perfusion index, carotid artery peak systolic velocity variability, IVC collapsibility index, IJV collapsibility index etc.

Michael A Frolich and Donald Caton (2002) implicated the role of baseline heart rate in estimating post spinal hypotension in obstetrical patients. Keeping a cut off value of 90 beats per minute, they allocated two groups

of patients having heart rate < 90 and > 90 beats. It was found that higher baseline heart rate reflects a higher sympathetic tone in a person. Individuals with higher sympathetic activity are more prone to develop hypotension as a result of spinal sympathetic blockade [15].

Cavallaro et al (2010) conducted a study to find the ability of passive leg raising induced changes in cardiac output (PLR-cCO) and in arterial pulse pressure (PLR-cPP) to predict fluid responsiveness. They concluded that passive leg raising-induced changes in cardiac output can reliably predict fluid responsiveness and has a significantly higher predictive value than PLR-cPP [22].

Ginosar .Y. Weiniger et al (2010) hypothesised that pulse oximeter perfusion index [PI] provides an earlier indication of sympathectomy following epidural anaesthesia than skin temperature and arterial pressure. A total 7 of 40 patients received lumbar epidural catheters and PI in the toe, mean arterial pressure, and toe temperature were assessed at baseline 5,10,15,20 minutes following epidural anaesthesia. Clinically sympathectomy was defined as 100% increase in perfusion index, 15% decrease in mean arterial pressure, 1° increase in toe temperature. They concluded that perfusion index was an earlier and sensitive indicator of sympathectomy [36].

S. Toyama, M. Kakumoto (2013) determined that higher baseline perfusion index reflected lower peripheral vascular tone and hence fall in systolic blood pressure was much more significant in parturients with high baseline perfusion index. A baseline perfusion index cut off point of 3.5 was used to identify patients at risk of hypotension. Duggappa et al (2017) also confirmed this finding in patients undergoing LSCS [37, 38]

Nahid Manouchehrian and team (2020) aimed to investigate the effect of using elastic bandage in the lower extremities to prevent post spinal hypotension in C-section. A total of 64 patients undergoing C-section with spinal anesthesia were enrolled and divided into two groups with bandaging and without bandaging at the time of the surgery. The

incidence rates of hypotension (25% vs. 78.1%), bradycardia (9.3% vs. 15.6%), and intraoperative nausea and vomiting (12.5% vs. 59.4%) were significantly lower in the intervention group than those reported for the control group. The administered amount of ephedrine (4.1±3.1 vs. 20.6±13.2 mg) was lower in the intervention group than that of the control group (P=0.01). The obtained results of the present study showed that bandaging the lower extremities in C-section with spinal anaesthesia, as an inexpensive available non-invasive procedure, can be effective in the prevention of post spinal hypotension and reduction of administered ephedrine [39].

Ayhan Kaydu et al (2019) investigated the usefulness of preoperative CIMT (Carotid intima-media thickness) measurement as a predictor of post-induction hypotension (PIH). The ultrasonographic measurement of CIMT was performed preoperatively on 82 patients. Hypotension developed in 41 patients. CIMT was higher in the patient group with PIH than in the group without PIH ($p < 0.001$). There was statistically significant correlation between MBP decrease after induction and CIMT ($r = 0.529$, $p < 0.0001$). CIMT correlated positively with age ($r = 0.739$, $p < 0.0001$). CIMT was an independent predictor of PIH after adjusting other factors with an odds ratio of 1.833 (95% CI 1.23-2.72; $p = 0.003$). The ultrasonographic imaging and measurement of CIMT can reliably predict hypotension with a 0.65-mm threshold level [23].

Multivariate logistic regression analysis was performed by Salama and Elkashlan (2019) to detect the most important predictors of post spinal hypotension and it was found that caval aorta index was the most significant predictor of it. The analysis showed that caval aorta index had a sensitivity of 96%, a specificity of 88%, and an accuracy of 95% to predict post spinal hypotension at a cut-off point less than 1.2. Whereas, IVC collapsibility index had a sensitivity of 84%, a specificity of 77% and an accuracy of 84% at a cut-off point more than 44.7% [10].

Zhang and Critchley (2016) suggested that ultrasound scanning of the IVC and measurement of the CI preoperatively provides a reliable predictor of hypotension after induction of general anesthesia in 75% of patients, wherein clinically relevant hypotension is defined as a decrease in MBP from baseline more than 30% or MBP lower than 60 mmHg. The ultrasonographic measurement of IVCCI which was done in 90 patients, had a good predictive value for hypotension, with a sensitivity of 78.6% and a specificity of 91.7% at a cut-off value of 43% [5].

Asta Macuiliene, Inna Jaremko (2018) conducted a study to evaluate the changes of inferior vena cava collapsibility index (IVC-CI) during SA in 60 spontaneously breathing patients during elective knee joint replacement surgery to prognose manifestation of intraoperative hypotension and bradycardia. Inspiratory and expiratory inferior vena cava (IVCin, IVCex) diameters were measured using an ultrasound device in supine position before and immediately after SA, then 15 min, 30 min, and 45 min after SA was performed. The heart rate, along with systolic, diastolic, and mean arterial blood pressures were collected. The parameters were measured at the baseline and at the next four time points. There were no significant changes in IVCin, IVCex, and IVC-CI compared to baseline and other time point measurements in hypotensive versus non hypotensive and bradycardic versus non bradycardic patients ($p > 0.05$). They concluded that reduction in IVC diameters and increase in IVC-CI do not predict hypotension and bradycardia during SA in spontaneously breathing patients [40].

Another study by Ceruti et al. (2020) compared IVCCI-guided fluid administration and no fluid preload infusion before spinal anesthesia in 160 patients. The overall rate of arterial hypotension after spinal anaesthesia was 35%; the IVCUS-group showed a lower incidence of arterial hypotension compared to the control group. The relative risk reduction in hypotension between the groups was 35%. Preoperative

IVCCI measurement was a reliable predictor of hypotension after induction of spinal anesthesia [41].

Pin Hung Yeh (2020) enrolled 80 full-term parturients with singleton pregnancies who underwent scheduled cesarean section and allocated to either a supine position group or a 15˚ left tilt group. He demonstrated that baseline CI could serve as a predictive indicator for post-spinal anesthesia hypotension in parturients regardless of the position of the patient. The post-anesthetic hypotension rate was 51.9%.CI and BMI were considered independent predictors that could affect the risk of post-spinal anesthesia hypotension. A left tilt of 15 degree did not contribute to the risk for hypotension [42].

A study by Yusuf Aslan and team (2021) in 73 geriatric patients concluded that the end expiratory vena cava inferior (expVCI) diameter value measured by USG before SA in older adults is effective in predicting post-spinal hypotension with lactate and pH values, which are among the blood gas parameters, and expVCI can be preferred to invasive methods because of its non-invasive, easy and fast application [43].

However, contrary to Pin Hung Yeh, Junli You (2022) investigated the effect of the 15 degree left operating table tilt on the inferior vena cava (IVC) and the hemodynamics of full-term pregnant women to evaluate the efficacy of inferior vena cava collapse index (IVCCI) in predicting hypotension. It was found that the 15 degree left operating table tilt improved the parameters of IVC, relieved the extent of compression of IVC and reduced the incidence of hypotension compared with the supine position. The higher the IVCCI score, the greater the likelihood of hypotension, which suggested that enlarged uterine compression of IVCCI was one of the causes of hypotension after CS under SA [44].

Ting-ting Ni, Zhen-feng Zhou (2022) conducted a study in which receiver operating characteristic (ROC) curve was used to determine the diagnostic value of IVCCI (inferior vena cava collapsibility index) for predicting post spinal hypotension and calculate the cut-off value. ROC

curve analysis revealed that IVCCI had a sensitivity of 83.9%, a specificity of 76.3%, and a positive predictive value of 84% for predicting post spinal anaesthesia hypotension at a cut-off point of > 42%. According to the cut-off variation value of 42%, the IVCCI-guided group exhibited a lower incidence of hypotension than the standard fluid administration group. Total fluid administered was lower in the IVCCI-guided group than in the standard group. Unlike the standard group in which all patients received one bolus of 5 mL/kg crystalloid, 62.7% of the patients in the IVCCI-guided group needed adjustment of fluid administration and 30.5% of the patients received two boluses of fluid administration, which suggested that IVCCI measurement could identify an individual patient's need for boluses of fluid preload [45].

Agarwal et al (2021) conducted a study on correlation of preoperative inferior vena cava diameter and inferior vena cava collapsibility index with preoperative fasting status, patient demography and general anaesthesia associated hypotension (GAAH). They concluded that, IVCCI and dIVCmax predicted hypotension with a diagnostic accuracy of 54% and 53%, respectively, thus demonstrating poor diagnostic performance. The dIVCmax ≤1.14 cm had a sensitivity of 31% and specificity of 87% in predicting GAAH. IVCCI ≥63.3% could predict GAAH with only 31% sensitivity and 84% specificity. The measurement of dIVCmax and IVCCI did not show any significant correlation with preoperative fasting, GAAH, environmental temperature and humidity [46].

Sumit. R Chowdhury and team (2022) predicted in that neither IVCCI nor carotid artery peak velocity variation (CAPVV) was able to predict PSH in 50 adult patients undergoing elective infra-umbilical surgery. They concluded that the different sensitivity of IVCCI and CAPVV was probably because the peak velocity in the carotid artery and IVC diameter is affected differently by the respiratory efforts and patterns in spontaneously breathing patients. Although the basic mechanism of PSAH is a pre-ganglionic sympathetic block produced by the local anaesthetics, it is

not explained by decreased pre-load or after-load. The pathophysiology of PSAH is multifactorial which includes circulatory effects of local anaesthetics, relative adrenal insufficiency, skeletal muscle paralysis, ascending medullary vasomotor block, and associated respiratory insufficiency [9].

Maitra *et al*. (2020) also reported CAPVV to be a poor predictor of post-induction hypotension in patients receiving general anaesthesia for elective surgeries. CAPVV >18.8% could predict hypotension with only 61.9% sensitivity and 67.4% specificity in their study [24].

Killu and team (2010) analysed in 31 ICU patients that IJV diameter collapsibility index of > 39% can be associated with hypovolemia. The statistical analysis found the best sensitivity of 87.5% and specificity of 100%, when IJV collapsibility index was ≥39%(33).

Aleksandr Urakov et al (2018) aimed at establishing the values of internal jugular vein anterior-posterior [AP] and medial-lateral sizes in patients with hypovolemia. In their study on 25 adult Intensive care unit patients, they found that anterior-posterior vein diameter in patients with hypovolemia was significantly less than medial-lateral vein diameter during inhalation as well as exhalation. The value of AP diameter < 7 mm was recorded in 20 out of 25 patients whereas contrary to that only 6 patients had medial lateral diameter < 7 mm. So change in AP diameter was found to be a better predictor in determining hypovolemia [47].

Bano et al (2018) conducted a study to evaluate the internal jugular vein (IJV) /common carotid artery (CCA) diameter ratio by ultrasound to estimate central venous pressure as a non-invasive tool for volume assessment. The study showed that there is a moderate correlation of the IJV/CCA diameter ratio at expiration with CVP (r = 0.401), there is a poor correlation in patients who are on the ventilator (r =0.343). Cut off < 2 for the IJV/CCA diameter, as reported by Nejad et al. showed a significant result for predicting a CVP < 10 cm H_2O but cut-off values of < 2 showed insignificant results (p>0.05) in their study. A new cut off < 1.75 was tried

which showed significant results (p = 0.028) with a sensitivity and specificity of 84.62% and 52.17% [48, 49].

Haitham Md Jassim et al (2019) enrolled 70 ICU patients in comparing the bedside ultrasound estimation of IJV collapsibility index with IVC collapsibility index and invasively monitored central venous pressure [CVP]. They calculated the IJV cross sectional area [CSA] collapsibility index at 0° and 30° head elevation position and found a significant correlation with invasively monitored CVP. The most suitable cut off value determined for collapsibility index for IJV CSA at 0 degree was >14.1 with sensitivity and specificity ranging 73%–82% in predicting CVP ≤ 10. A cutoff value >19 was found to be an optimum for collapsibility index for IJV CSA at 30°with sensitivity and specificity ranging 73%–83% in accurately predicting CVP ≤10. IJV sonography imaging was easy to obtain in all the patients, whereas IVC imaging was not possible in almost 20% of patients due to various reasons like abdominal gas shadow and obesity [50].

Kilic et al (2020) focused on the determination of IJV sonographic examination in prediction of post spinal hypotension. The study included 47 patients and the analysis showed that IJV collapsibility index had a sensitivity of 64% and a specificity of 63.6% to predict the postspinal hypotension at a cut-off point of 22.6%. Compared to IVC imaging, sonographic evaluation of IJV was easier and time-saving. Additionally, it was found that IVC imaging cannot be possible in a group of patients, due to abdominal gas shadow and obesity. Moreover, anaesthesiologists are more familiar to IJV anatomy as they frequently perform ultrasound-guided central IJV catheterization in their routine practice [6].

Bassant M. Abdelhamid (2022) conducted a study in 73 adult patients and hypothesised that the IJV-CI (internal Jugular Vein Collapsibility Index) and the rates of change in IJV-D (IJV-diameter) and IJA-A (IJV-area) when measured in the supine and trendelenburg positions would be good predictors for PSAH in the elderly population. IJV-CI and ΔIJV-D and ΔIJV-A with position were significantly higher in the elderly surgical

patients who developed PSAH (Post Spinal Anaesthesia Hypotension).The IJV-CI and ΔIJV-D were the independent predictors for PSAH with a moderate predictive ability when their baseline values were >34.4 for the CI and >0.11 for the ΔJV-D, while carotid intima media thickness could not predict PSAH [51].

Ahmed Elasyed Ibrahim et al (2022) concluded that ultrasonographic measurement of venous parameters of IJV provides a useful non-invasive tool for assessment of intravascular volume status in critically ill patients. The study was carried out on 67 patients of both sexes for the bedside assessment of central venous pressure/fluid status in critical ill intensive care unit patients. There were a statistically significant decrease in all CI (Collapsibility indices) among cases had CVP > 10 mmHg compared to cases had CVP ≤ 10. CI of IJV at 0º at cut off > 21.4 had sensitivity 88.4%, specificity 79.2% and accuracy 85.1% in prediction of CVP ≤ 10 while at 30º at cut off 20.7 had sensitivity 90.7%, specificity 83.3% and accuracy 88.1% in prediction of CVP ≤ 10 mmHg. Finally, CI of IVC at cut off > 31.75 had sensitivity 74.4%, specificity 70.8% and accuracy 73.1% in prediction of CVP ≤ 10 mmHg among the studied cases [52]

In another study Avcil et al (2015) formulated that the height and diameter of IJV correlated moderately with CVP whereas IVC diameter and its collapsibility index correlated poorly with CVP. They concluded that height of right IJV and IVC index has better diagnostic performance for estimating higher CVP, whereas IJV cross sectional area, maximum diameter and IVC maximum diameter showed greater sensitivity and negative predicitive value for estimating low CVP. The low ability of jugular vein and inferior vena cava diameter measurements to reflect high CVP, but perform well in low CVP situations, was explained by the physiology of the venous structures. Such structures can expand to a certain point when the CVP increases and then, the expansion ratios do not significantly change, even though the CVP may increase. When the CVP increases, the expansion of the vein diameter stops, but the column may continue to

rise upward. Again, the capability of the IVC index in reflecting high CVP levels conforms to the vein physiology. While the CVP increases, vein diameter enlargement stops, and it does not collapse during the expiration after the CVP exceeds a specific limit [53].

Bauman Z et al. (2015) demonstrated a significant correlation between IJV-CI and IVC-CI during spontaneous ventilation. At the same time, it was non-significant with increased thoracic or intra-abdominal pressure. The authors denoted that an increased intra- abdominal pressure up to 15 mmHg by gas insufflation during laparoscopic surgeries was associated with a 24% decrease in the IVC-D. Therefore, IJV measurements can represent an alternative when the visualisation of the IVC is difficult, or its measurement is influenced [54].

Amr Arafa Elbadry, Ahmed el dabe (2021) showed that both IVCCI and IJVCI could be used as reliable markers to predict PSAH occurrence in pregnant females, with a slight superiority for IVCCI (AUC = 0.950 and 0.898 for IVC and IJV, respectively). They proved that for IVCCI, a cut-off point of 33% had sensitivity and specificity of 84.6 and 93.1%, respectively, for predicting PSAH, with a diagnostic accuracy of 89.1%. Additionally, IJVCI had sensitivity and specificity of 84.6 and 82.8%, respectively, for predicting the same complication using a cut-off value of 38.5% [55].

In line with their results, Brolio and his associates reported that IVC diameter changes were a marker for fluid responsiveness. Furthermore, Prekker et al. found a good relationship between the maximum IVC diameter and the internal jugular aspect ratio. Therefore, they proved that if one technique is reliable, the other will also be dependable [56].

So all the above studies provided us a good reference as non-invasive parameters of depicting hypovolemia and low CVP in operative and ICU patients. In order to prevent post spinal hypo-perfusion, these parameters can provide us an extra edge over invasive methods for early and timely

management. Therefore, we had planned to compare IVC and IJV diameter collapsibility index in prediction of post spinal hypotension.

MATERIALS AND METHODS

7.1 SOURCE OF DATA

This prospective, cross sectional, observational study was conducted in Department of Anaesthesiology, Dayanand Medical College & Hospital, Ludhiana after approval by Institutional Ethics Committee on a total of 50 adult patients posted for elective surgery under spinal anaesthesia. A written informed consent was obtained from all patients.

7.2 METHOD OF COLLECTION OF DATA

Inclusion Criteria

- Patients > 18 years of age.
- Patients undergoing spinal anaesthesia for an elective surgery.
- ASA I, II, III patients.

Exclusion Criterion

- Consent refusal by the patient for study
- Infection at the site of spinal injection
- Patients with severe hypovolemia or haemorrhagic shock
- Pre-existing severe neurological, cardiac, renal or liver disease
- Thrombocytopenia and Coagulopathies
- Patient currently taking anti-coagulant/anti-platelet therapy
- Spine injury

PRE ANAESTHETIC CHECKUP

A complete pre anaesthetic check-up was done which included detailed history including allergy to any drug, pre-existing co-morbidities and medication history, general, physical and systemic examination and relevant laboratory investigations as per institutional protocol. The demographic details including age, sex, height, weight and BMI etc. were recorded. Patient was explained about the study protocol and a written informed consent was obtained.

ANAESTHESIA TECHNIQUE:

After shifting the patient into operating room, the patient was positioned supine on operating table. Standard monitoring with electrocardiography,

automated non-invasive blood pressure measurement and pulse oximetry was initiated. IV access was established using an 18G cannula. Baseline values of HR, SpO_2, systolic, diastolic and mean blood pressure were recorded.

A curvilinear USG probe of 1-5 MHz was used for IVC imaging. The transducer was placed in the subxiphoid region in a longitudinal position and measurements were made just distal to the IVC-hepatic vein junction, approximately 3 to 4 cm distal to the right atrium. The IVC was identified by Doppler waveform, compressibility and phasic collapse with respiration. The maximum (IVCD) and minimum (IVCD) internal antero-posterior (AP) diameters of the IVC at the end of expiration and inspiration respectively over one respiratory cycle were measured using M mode.

IVC Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

For IJV measurements, a linear ultrasound probe of 13 MHz was placed on the right side of the neck in transverse plane over right internal jugular vein 2 cm above sterno-clavicular joint just lateral to cricoid cartilage. We preferred right IJV over left IJV as diameters in right IJV are significantly larger than left IJV. Care was taken not to compress or obliterate the vein by applying minimal pressure.

The transducer was held perpendicular to the skin and parallel to the cricoid cartilage. The changes in anterior-posterior [AP] diameter of internal jugular vein were recorded during one respiratory cycle (inhalation and exhalation) and the collapsibility index was derived using M mode, using the formula:

IJV Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

After the above measurements, another reading of IJV maximum and minimum diameters was taken with patient's head elevated at 30 degree.

Co-loading with 500 ml normal saline infusion was started in every patient after recording baseline collapsibility indices of IVC and IJV and sub arachnoid block was performed with patient in sitting position under all aseptic precautions. A 26G Quincke needle was inserted in the space between L3 and L4 vertebrae and after obtaining free flow of clear CSF, 10 mg 0.5 % hyperbaric Bupivacaine (2ml) along with 25µg Fentanyl (0.5ml) was injected intrathecally.

The patient was shifted to supine position immediately. Patients' non-invasive blood pressure and heart rate were recorded every 1 minute for first ten minutes and then every 2 minutes for next 20 minutes after spinal anaesthesia. Assessment of loss of cold sensation was done every 2 minutes with spirit swab to check the highest level of sensory block achieved till 30 minutes. Motor block was checked by voluntary lifting of legs by the patient using modified Bromage Scale. Time taken to achieve the highest sensory and motor levels was recorded.

Bradycardia was defined as heart rate going below 60 beats per minute and was treated with IV administration of 0.6mg atropine.

Hypotension was defined as fall in systolic blood pressure > 30% from the baseline or any episode of systolic pressure going below 90mm of Hg. Whenever hypotension occurred, the patient was managed by rapid fluid administration and incremental doses of 6mg ephedrine boluses every 3-4 minutes according to the requirement for maintaining the blood pressure within normal range. Concomitant Oxygen administration using venture mask was also started if patient developed significant bradycardia or hypotension. If hypotension still persisted, nor-epinephrine infusion at 3-10µg/kg/min was started and dose was appropriately adjusted.

The incidence and severity of fall in blood pressure was recorded and co-related to baseline Inferior vena cava and Internal jugular vein diameter collapsibility index.

Outcome:

PRIMARY OUTCOME

The study compared the efficacy of inferior vena cava and internal jugular vein collapsibility index in prediction of hypotension in patients undergoing spinal anaesthesia.

SECONDARY OUTCOME

The study also compared the IJV collapsibility index at 0^{o} and 30^{o} head elevated positions, in prediction of post spinal hypotension.

STATISTICAL ANALYSIS

Study design: Observational, Prospective, Cross Sectional Study

Sample Size: Sample size calculation for this study was done by the following formula:

Sample size based on sensitivity = $\frac{Z^2 * S_N * (1-S_N)}{L^2 * p}$

Sample size based on specificity = $\frac{Z^2 * S_P * (1-S_P)}{L^2 * (1-p)}$

Where S_N-Sensitivity, S_P- Specificity

p- Incidence rate of hypotension (45%)

L- absolute precision desired on either side of sensitivity and specificity

Z- standard normal deviate corresponding to the specified size of critical region (α)

For IJV [4],

For sensitivity of 64%, the sample size by the above formula was 40

For a specificity of 64%, the sample size calculation was 32

For IVC [5],

For sensitivity of 84%, the sample size by the above formula was 23

For a specificity of 77%, the sample size calculation was 25

Therefore, for this study, the higher value, that was 40 had been taken. So, total sample size taken was 50.

OBSERVATION AND RESULTS

This prospective, observational study was conducted in Department of Anaesthesiology, Dayanand Medical College & Hospital, Ludhiana on a total of 50 adult patients above 18 years of age undergoing spinal anaesthesia for an elective surgery. The aim of the study was to compare efficacy of Inferior vena cava collapsibility index and internal jugular vein collapsibility index in prediction of hypotension after spinal anaesthesia.

DEMOGRAPHIC PROFILE

Table 1: SEX DISTRIBUTION

Sex	No. of cases	Percentage
F	6	12.0%
M	44	88.0%
Total	50	100.0%

The study was conducted on patients of both sexes with ASA grading of I, II and III. However, there were 44 males (88%) and 6 females (12%). The demographic profile of the patients is as under:

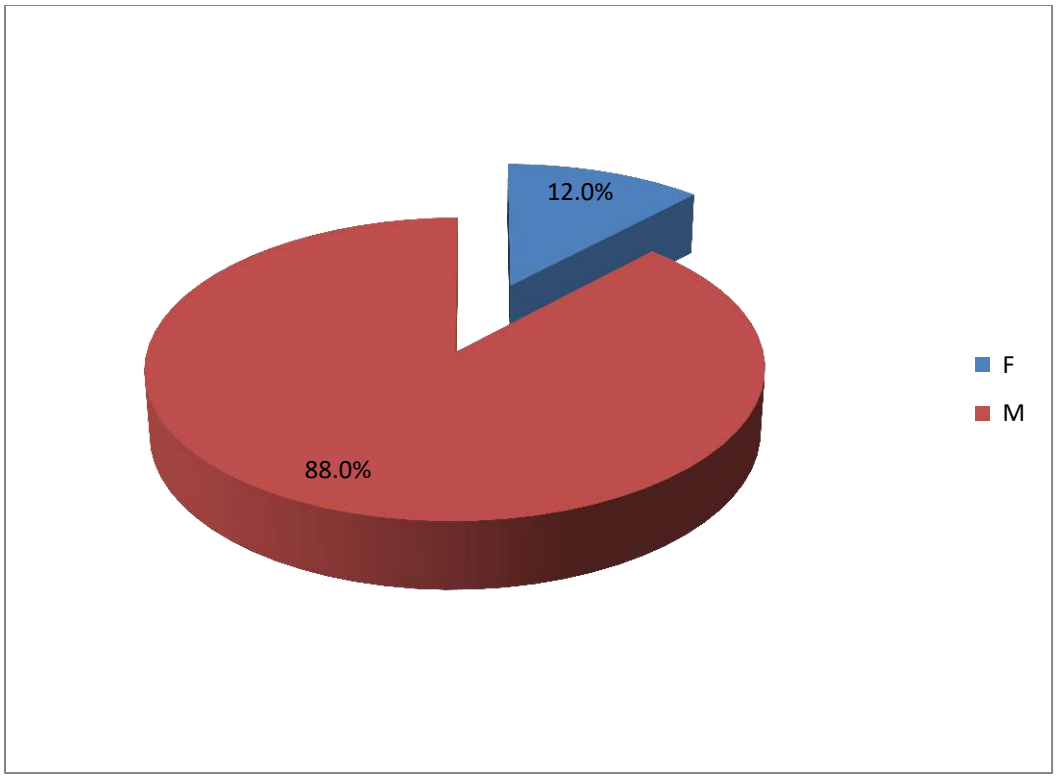

Figure 1: SEX DISTRIBUTION

Table 2: ASA GRADE OF THE PATIENTS

ASA Grade	No. of cases	Percentage
I	25	50.0%
II	15	30.0%
III	10	20.0%
Total	50	100.0%

Among 50 patients, 25 patients (50%) were having ASA I grade, 15 patients (30%) were of ASA II grade and remaining 10 patients (20%) were of ASA III grade.

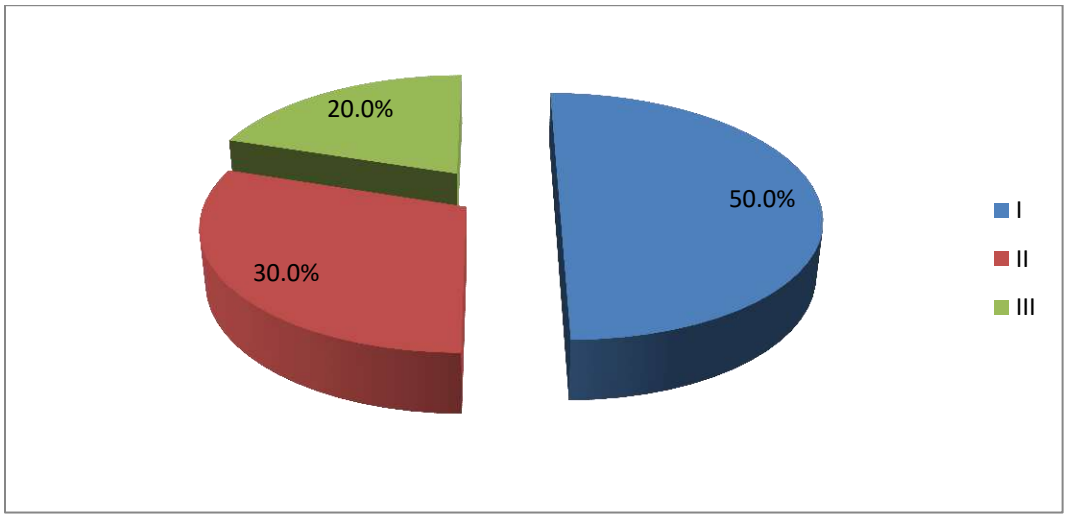

Figure 2: ASA GRADE OF THE PATIENTS

Table 3: AGE, WEIGHT AND BMI

	N	Minimum	Maximum	Mean	Std. Deviation
Age	50	18.00	82.00	49.84	19.06
Weight (Kg)	50	40.00	91.00	67.04	12.55
BMI (Kg/m2)	50	15.90	29.70	22.74	3.57

No significant difference was seen with respect to age, weight, height and body mass index (BMI) of the patients. Mean age of the patients was 49.84± 19.06, mean weight was 67.04± 12.55 and mean BMI was 22.74± 3.57

Table 4: PAST HISTORY OF THE PATIENTS

Past History	No. of cases	Percentage
	29	58.0%
CAD	1	2.0%
CAD, DM	1	2.0%
CKD	1	2.0%
DM	3	6.0%
DM, HTN	1	2.0%
HTN	8	16.0%
HTN, CAD	2	4.0%
HTN, CAD, DM	1	2.0%
HTN, DM	2	4.0%
HTN, DM, CKD	1	2.0%
Total	50	100.0%

Past history of all the patients was taken and any associated co-morbidities like coronary artery disease (CAD), hypertension (HTN), diabetes mellitus (DM) and chronic kidney disease (CKD) were noted in the study. Twenty nine patients (58%) had no associated co-morbidity.

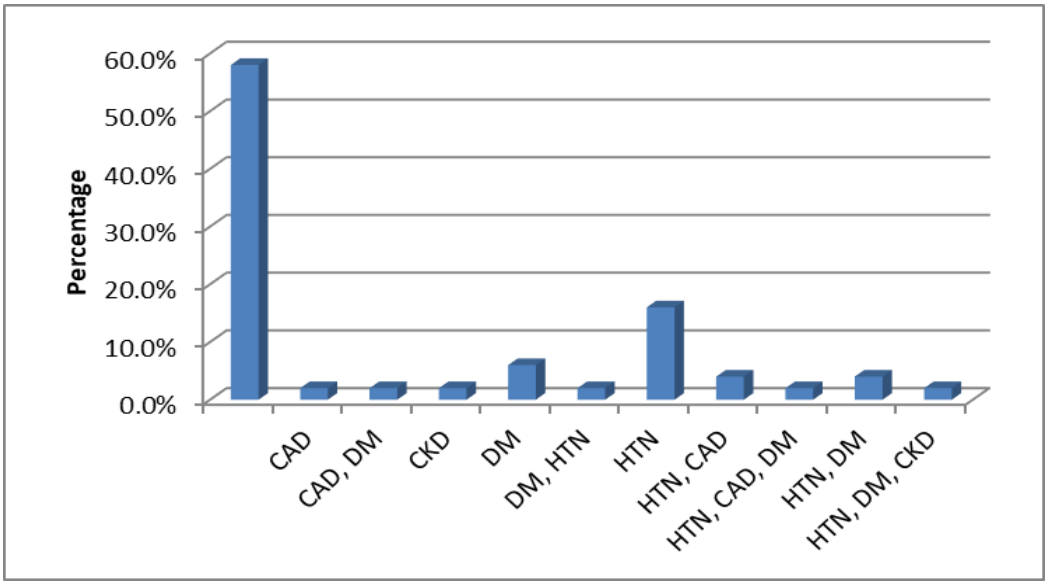

Figure 3: PAST HISTORY OF THE PATIENTS

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Table 5: HAEMODYNAMIC PARAMETERS

Pulse rate	50	59.00	110.00	79.58	12.82
SpO2	50	95.00	100.00	99.42	1.05
SBP	50	110.00	182.00	137.16	18.34
DBP	50	60.00	100.00	76.52	9.01
Respiratory rate	50	12.00	18.00	15.38	1.18

All the patients had comparable pre-op haemodynamic parameters and no statistical difference was observed in terms of pulse rate (79.58± 12.82), SpO2 (99.42± 1.05), systolic blood pressure (137.16± 18.34), diastolic blood pressure (76.52± 9.01) and respiratory rate (15.38± 1.18) of the patients

Table 6: IVC PARAMETERS

	N	Minimum	Maximum	Mean	Std. Deviation
IVC_maximum diameter(cm)	50	0.61	2.92	1.48	0.44
IVC_Minimum diameter (cm)	50	0.32	2.50	1.00	0.44
IVC collapsibility index	50	3.00	69.00	33.08	15.25

The IVC maximum diameter (1.48± 0.44) and IVC minimum diameter (1.00± 0.44), IJV maximum diameter (0.99± 0.29) and IJV minimum diameter (0.70± 0.28) at 0º plus IJV maximum diameter (0.79± 0.29) and IJV minimum diameter (0.51± 0.27) diameter at 30º was measured using ultrasound before applying spinal anaesthesia in all patients.

IVC collapsibility index (33.08± 15.25), IJV collapsibility index at 0º (30.14± 12.75) and IJV collapsibility index at 30º (36.16± 14.85) was calculated after measuring the above diameters.

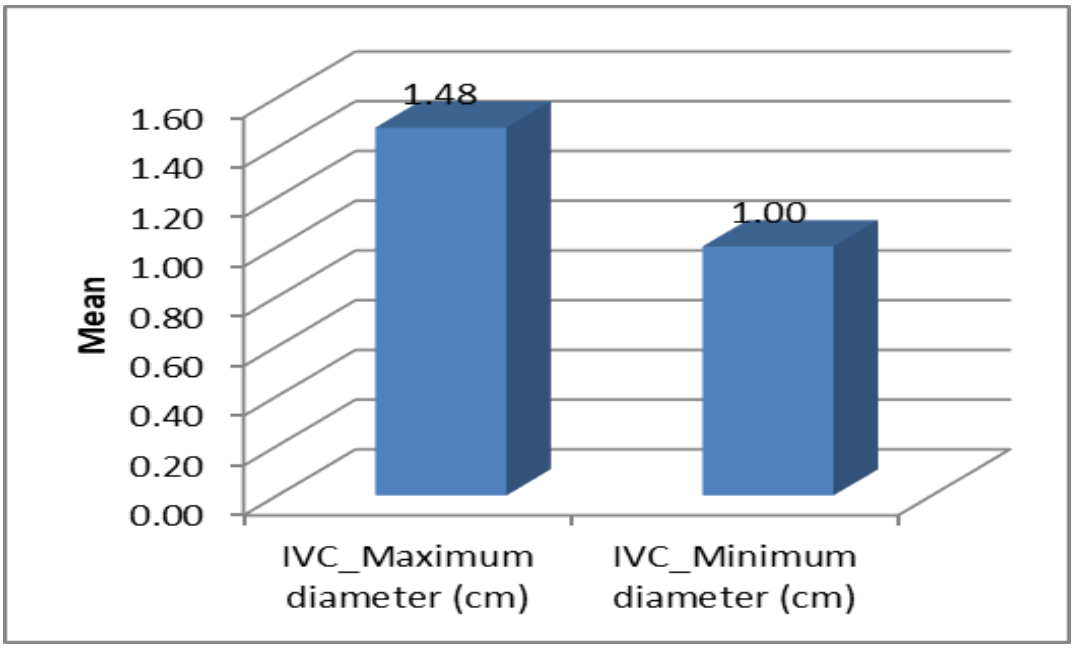

Figure 4: IVC DIAMETER

Table 7: IJV PARAMETERS

	N	Minimum	Maximum	Mean	Std. Deviation
IJV 0_Maximum diameter (cm)	50	0.51	1.68	0.99	14.85
IJV 0_Minimum diameter (cm)	50	0.24	1.45	0.70	14.85
IJV 0_IJV collapsibility index	50	2.90	61.00	30.14	14.85
IJV 30_Maximum diameter (cm)	50	0.22	1.50	0.79	14.85
IJV 30_Minimum diameter (cm)	50	0.15	1.32	0.51	14.85
IJV 30_IJV collapsibility index	50	4.00	70.00	36.16	14.85

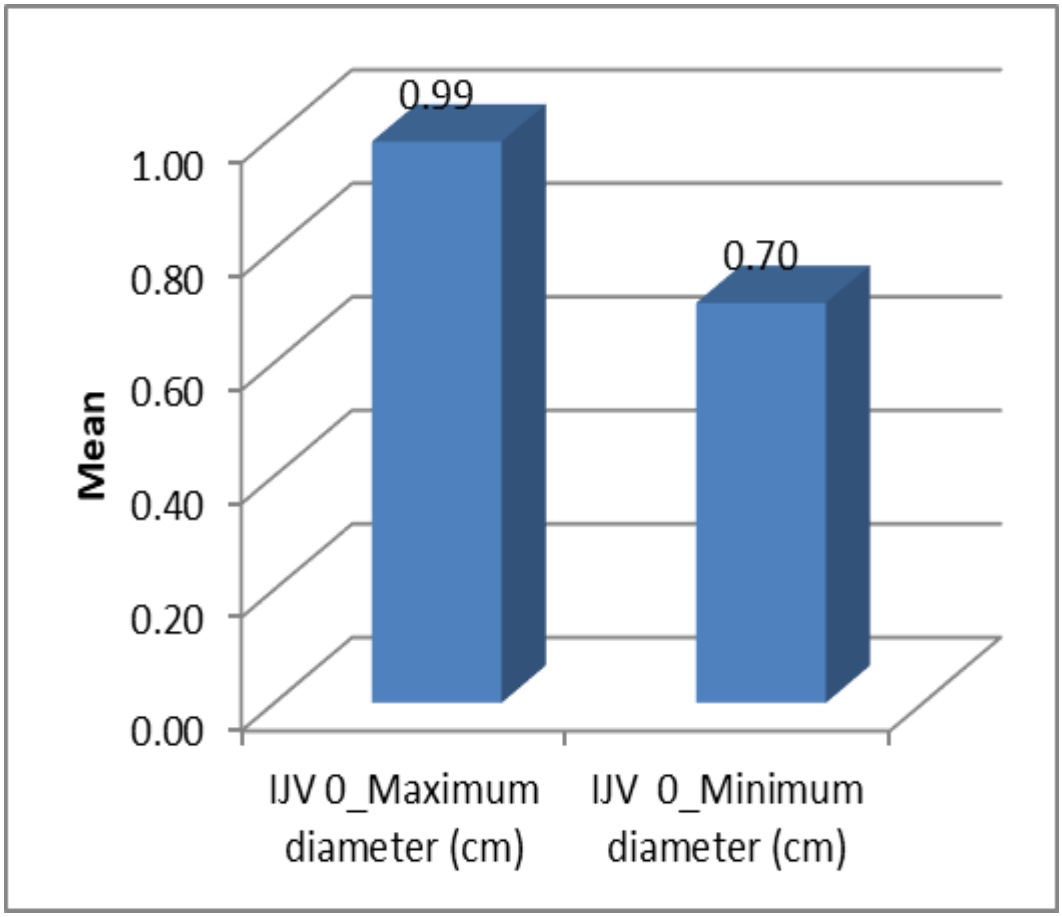

Figure 5: IJV DIAMETER AT 0º

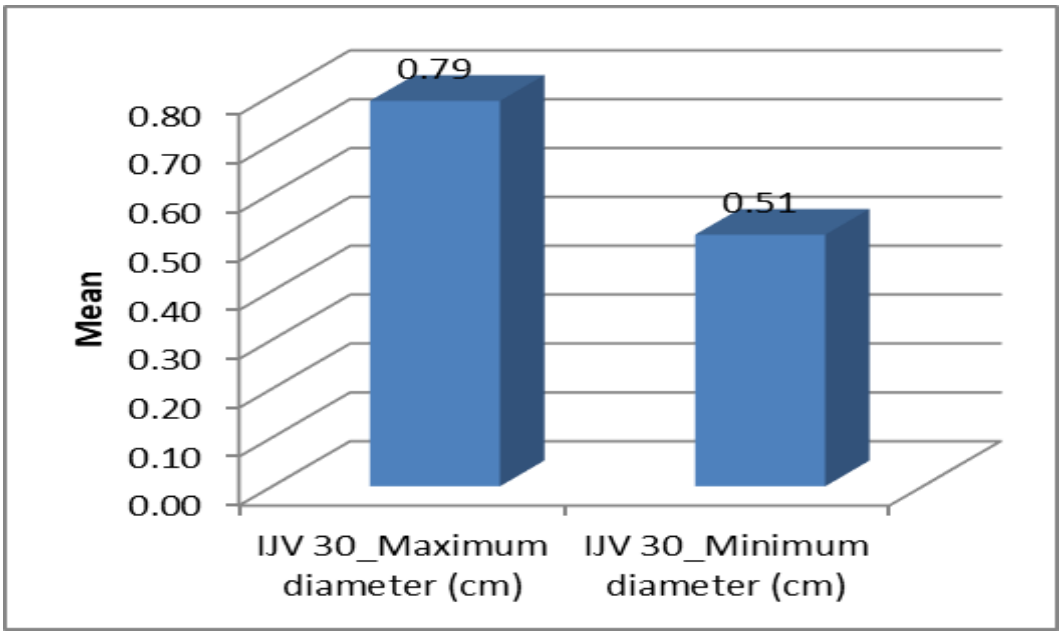

Figure 6: IJV DIAMETER AT 30º

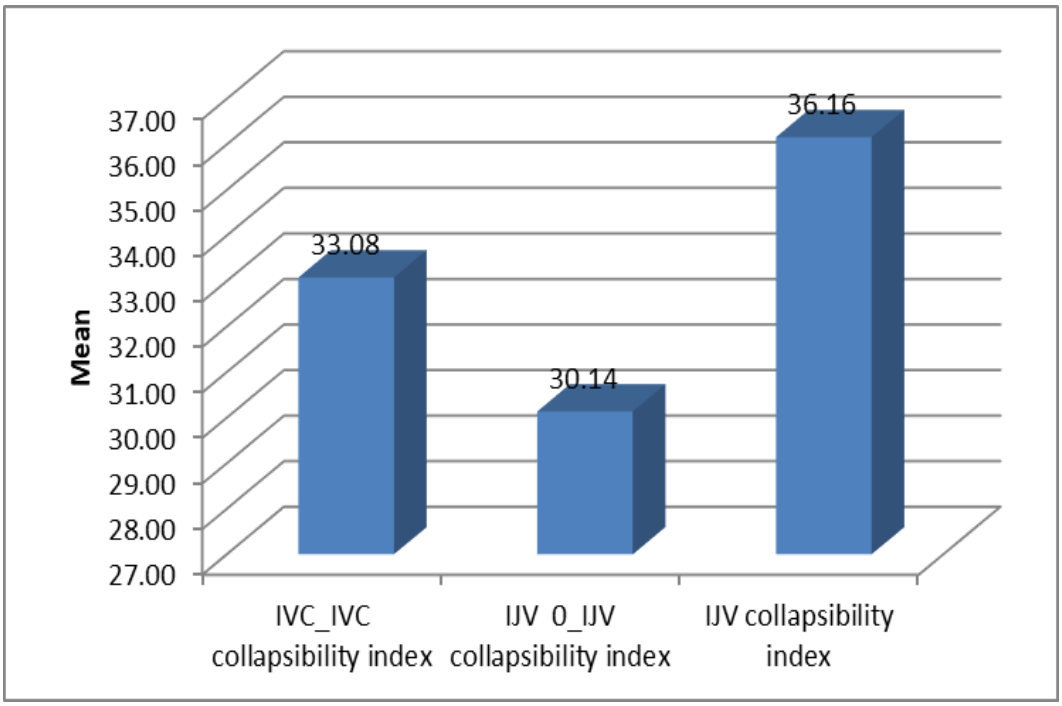

Figure 7: IVC COLLAPSIBILITY INDEX, IJV 0º COLLAPSIBILITY INDEX AND IJV 30º COLLAPSIBILITY INDEX

The heart rate, systolic, diastolic and mean blood pressure readings were recorded till 30 minutes after giving spinal anaesthesia in every patient.

Table 8: INTRA OP HEART RATE

	N	Minimum	Maximum	Mean	Std. Deviation
HR_Baseline	50	59.00	118.00	82.48	14.57
HR_0 Minute	50	60.00	118.00	81.98	13.59
HR_1 Minute	50	61.00	114.00	82.14	13.56
HR_2 Minute	50	59.00	112.00	81.90	14.12
HR_3 Minute	50	53.00	113.00	80.70	14.15
HR_4 Minute	50	59.00	113.00	81.48	13.90
HR_5 Minute	50	51.00	111.00	80.82	14.13
HR_6 Minute	50	59.00	108.00	80.82	13.71
HR_7 Minute	50	55.00	110.00	80.90	14.25
HR_8 Minute	50	60.00	113.00	80.46	13.78
HR_9 Minute	50	59.00	110.00	79.92	13.63
HR_10 Minute	50	59.00	106.00	78.50	12.75
HR_12 Minute	50	53.00	108.00	77.78	13.73
HR_14 Minute	50	59.00	106.00	78.26	13.37
HR_16 Minute	50	60.00	117.00	78.56	13.89
HR_18 Minute	50	59.00	108.00	77.78	13.43
HR_20 Minute	50	59.00	109.00	76.88	13.65
HR_22 Minute	50	60.00	113.00	76.38	13.88
HR_24 Minute	50	59.00	124.00	75.80	14.66
HR_26 Minute	50	60.00	117.00	75.72	14.06
HR_28 Minute	50	59.00	116.00	74.84	13.84
HR_30 Minute	50	59.00	123.00	74.72	14.22

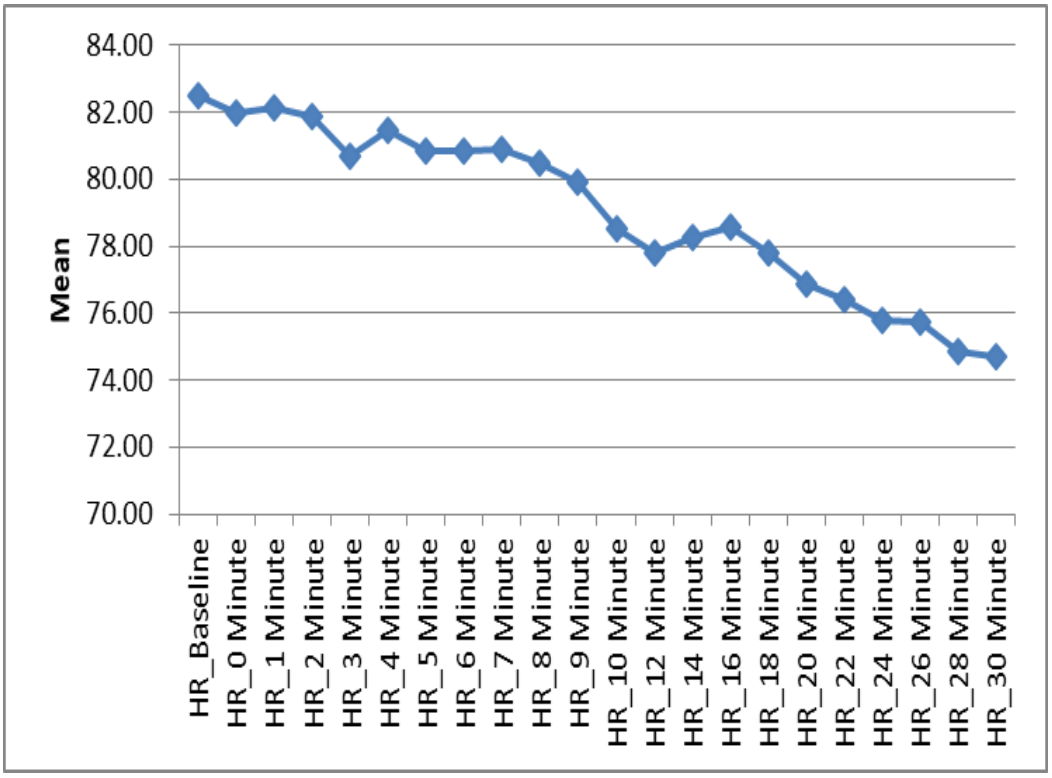

Figure 8: INTRA OP HEART RATE

Table 9: INTRA OP SYSTOLIC BLOOD PRESSURE

	N	Minimum	Maximum	Mean	Std. Deviation
SBP_Baseline	50	104.00	197.00	139.34	21.18
SBP_0 Minute	50	100.00	191.00	138.38	21.64
SBP_1 Minute	50	109.00	181.00	137.40	19.83
SBP_2 Minute	50	80.00	176.00	133.22	19.37
SBP_3 Minute	50	97.00	178.00	131.34	18.62
SBP_4 Minute	50	100.00	177.00	129.66	17.27
SBP_5 Minute	50	90.00	172.00	127.38	17.40
SBP_6 Minute	50	88.00	177.00	127.00	17.70
SBP_7 Minute	50	88.00	175.00	126.16	17.88
SBP_8 Minute	50	22.00	176.00	122.48	22.07
SBP_9 Minute	50	93.00	164.00	123.38	16.15
SBP_10 Minute	50	94.00	160.00	123.64	14.39
SBP_12 Minute	50	86.00	162.00	122.94	14.87
SBP_14 Minute	50	80.00	162.00	121.88	15.10
SBP_16 Minute	50	90.00	163.00	122.44	14.16
SBP_18 Minute	50	90.00	172.00	122.74	15.33
SBP_20 Minute	50	84.00	176.00	120.94	16.60
SBP_22 Minute	50	84.00	161.00	122.06	14.96
SBP_24 Minute	50	91.00	164.00	121.06	14.54
SBP_26 Minute	50	90.00	169.00	121.10	14.71
SBP_28 Minute	50	88.00	161.00	121.70	15.28
SBP_30 Minute	50	86.00	159.00	120.44	15.52

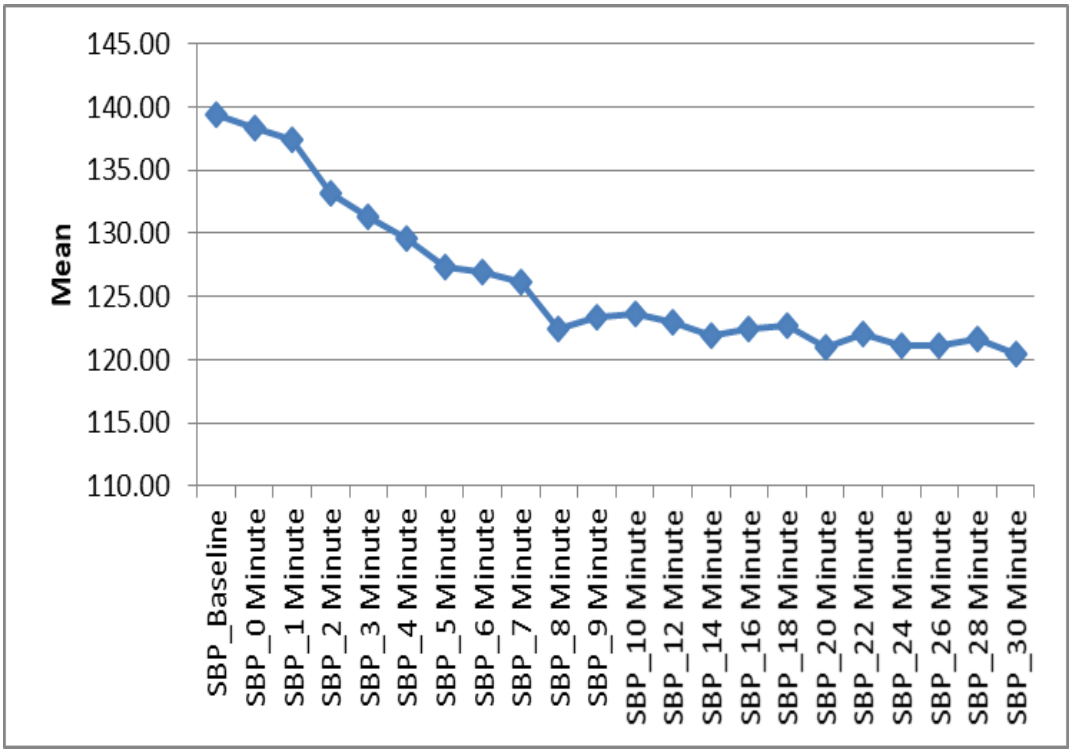

Figure 9: INTRA OP SYSTOLIC BLOOD PRESSURE

Table 10: PERCENTAGE OF PATIENTS HAVING HYPOTENSION

Hypotension	No. of cases	Percentage
n	43	86.0%
y	7	14.0%
Total	50	100.0%

Hypotension occurred in 7 patients (14%) out of 50 and four patients (8%) had bradycardia after spinal anaesthesia. The highest level of sensory and motor block was comparable in all patients and their effect on patient's haemodynamics was insignificant.

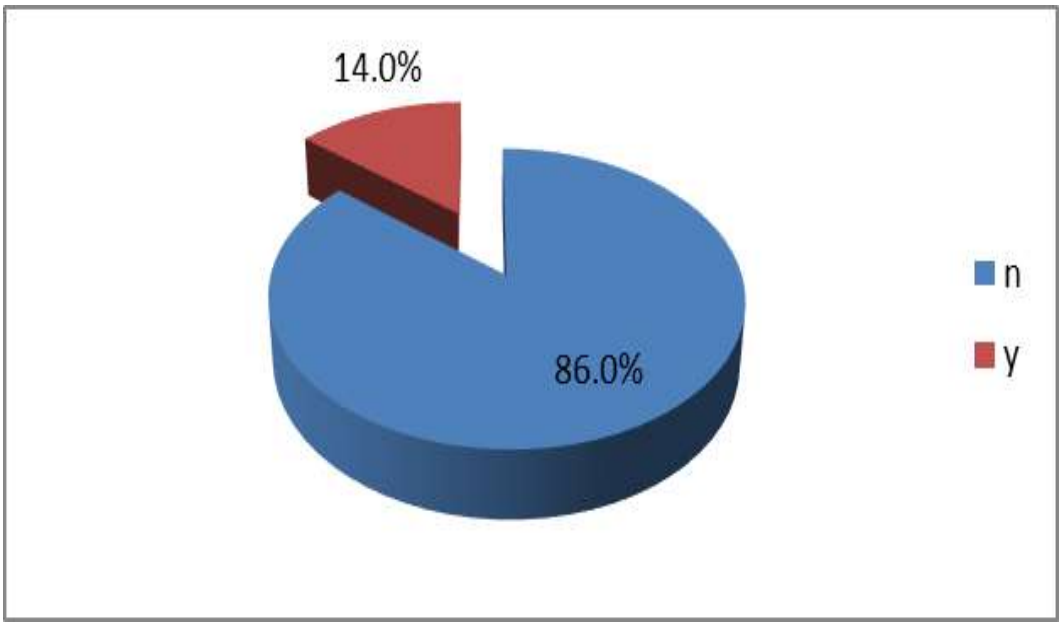

Figure 10: PERCENTAGE OF PATIENTS HAVING HYPOTENSION

Table 11: PERCENTAGE OF PATIENTS HAVING BRADYCARDIA

Bradycardia	No. of cases	Percentage
n	46	92.0%
y	4	8.0%
Total	50	100.0%

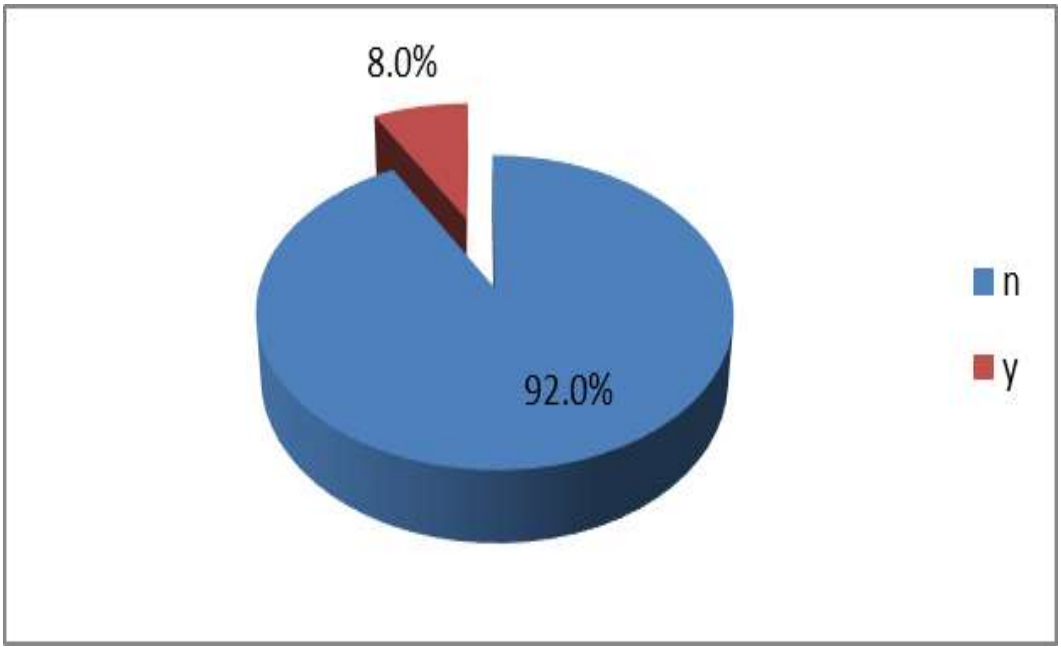

Figure 11: PERCENTAGE OF PATIENTS HAVING BRADYCARDIA

Table 12: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 43%.

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IVC_IVC collapsibility index	< 43	32	74.4%	4	57.1%	36	0.891	0.345
	> 43	11	25.6%	3	42.9%	14		
Total		43	100.0%	7	100.0%	50		

At a cut off value of 43%, IVC collapsibility index (IVCCI) had a sensitivity and specificity of 42.86% and 74.42% respectively, with NPV of 88.89% in prediction of post spinal anaesthesia hypotension (PSAH).

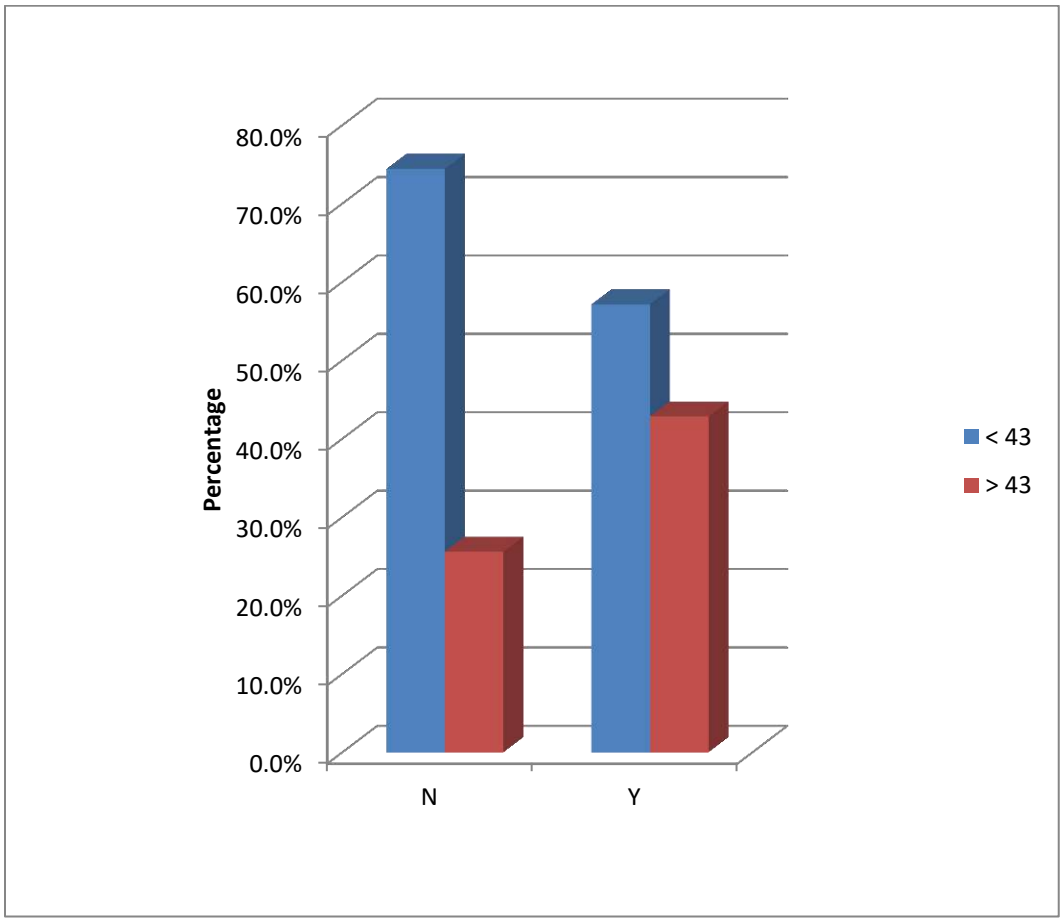

Figure 12: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 43%.

Table 13: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 43%.

Statistic	Value	95% CI
Sensitivity	42.86%	9.90% to 81.59%
Specificity	74.42%	58.83% to 86.48%
Positive Likelihood Ratio	1.68	0.62 to 4.53
Negative Likelihood Ratio	0.77	0.39 to 1.49
Disease prevalence (*)	14.00%	5.82% to 26.74%
Positive Predictive Value (*)	21.43%	9.15% to 42.47%
Negative Predictive Value (*)	88.89%	80.45% to 93.96%
Accuracy (*)	70.00%	55.39% to 82.14%

Table 14: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39%.

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 0º collapsibility index	< 39	36	83.7%	5	71.4%	41	0.616	0.432
	> 39	7	16.3%	2	28.6%	9		
Total		43	100.0%	7	100.0%	50		

For IJV collapsibility index (IJVCI) at 0º, a cut off value of 39% had sensitivity and specificity of 28.57% and 83.72% respectively, with NPV of 87.80% for PSAH prediction.

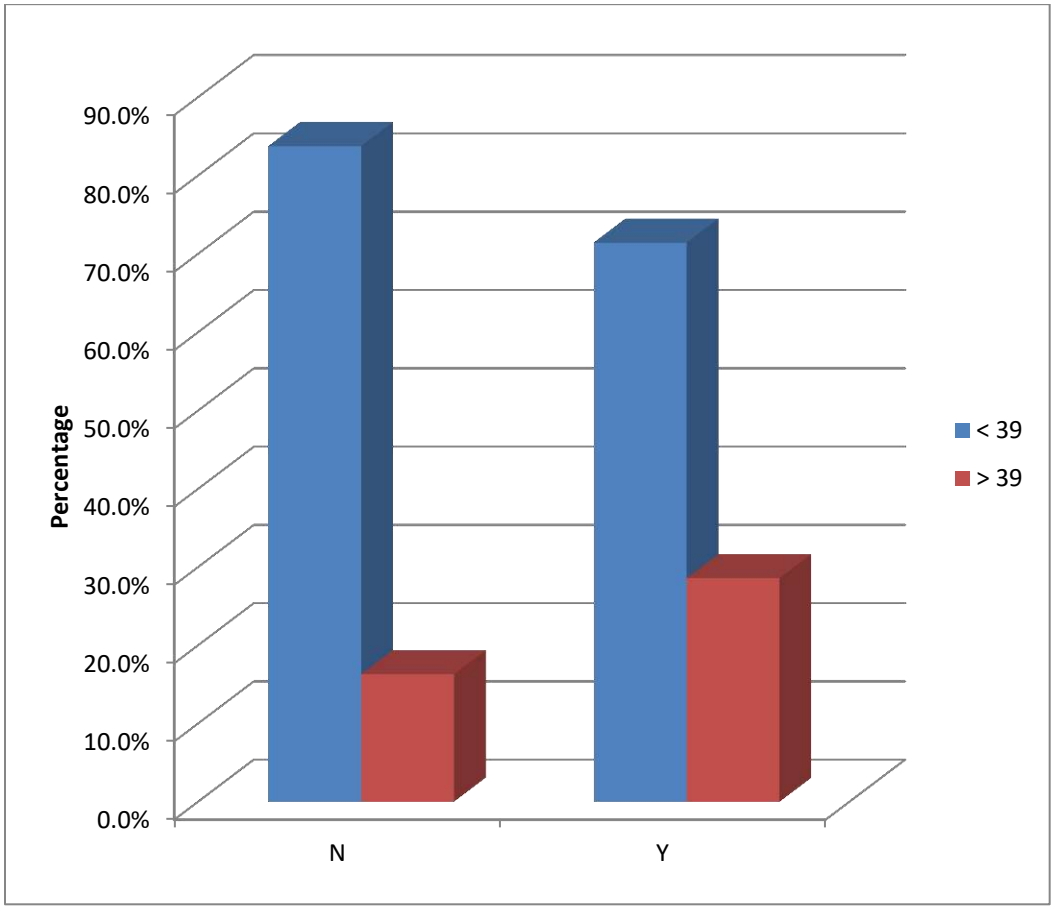

Figure 13: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39%.

Table 15: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39%.

Statistic	Value	95% CI
Sensitivity	28.57%	3.67% to 70.96%
Specificity	83.72%	69.30% to 93.19%
Positive Likelihood Ratio	1.76	0.45 to 6.79
Negative Likelihood Ratio	0.85	0.52 to 1.39
Disease prevalence (*)	14.00%	5.82% to 26.74%
Positive Predictive Value (*)	22.22%	6.87% to 52.51%
Negative Predictive Value (*)	87.80%	81.57% to 92.13%
Accuracy (*)	76.00%	61.83% to 86.94%

Table 16: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39%.

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 30º collapsibility index	< 39	25	58.1%	5	71.4%	30	0.443	0.506
	> 39	18	41.9%	2	28.6%	20		
Total		43	100.0%	7	100.0%	50		

IJVCI at 30º at same cut off value of 39% had sensitivity and specificity of 28.57% and 58.14% respectively, along with NPV of 83.33%. All the results for IVCCI and IJVCI (0º and 30º) at a cut off value of 43% and 39% respectively, were insignificant (p value >0.05).

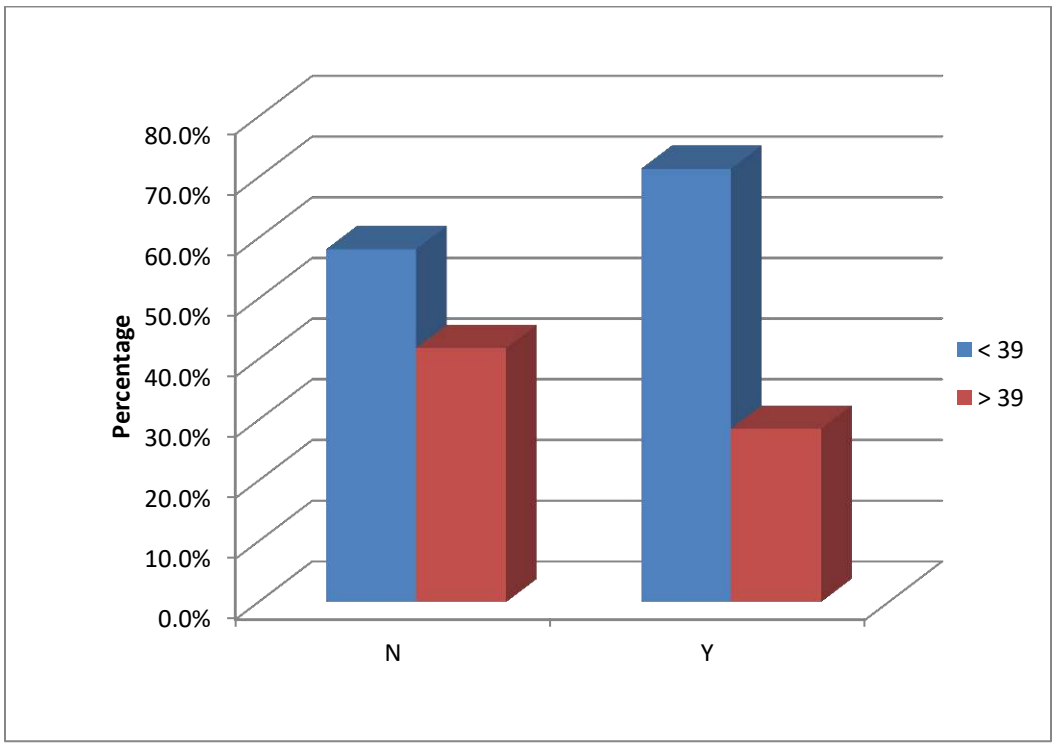

Figure 14: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39% .

Table 17: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 39%.

Statistic	**Value**	95% CI
Sensitivity	**28.57%**	3.67% to 70.96%
Specificity	**58.14%**	42.13% to 72.99%
Positive Likelihood Ratio	**0.68**	0.20 to 2.32
Negative Likelihood Ratio	**1.23**	0.72 to 2.09
Disease prevalence (*)	**14.00%**	5.82% to 26.74%
Positive Predictive Value (*)	**10.00%**	3.17% to 27.41%
Negative Predictive Value (*)	**83.33%**	74.59% to 89.49%
Accuracy (*)	**54.00%**	39.32% to 68.19%

Table 18: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 38%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IVC collapsibility index	< 38	29	67.4%	1	14.3%	30	7.087	0.012
	> 38	14	32.6%	6	85.7%	20		
Total		43	100.0 %	7	100.0%	50		

IVCCI at a cut off value of 38% correlated well with spinal hypotension, and had a sensitivity and specificity of 85.71% and 67.44% respectively, with NPV of 96.67% and accuracy of 70% (p value =0.012).

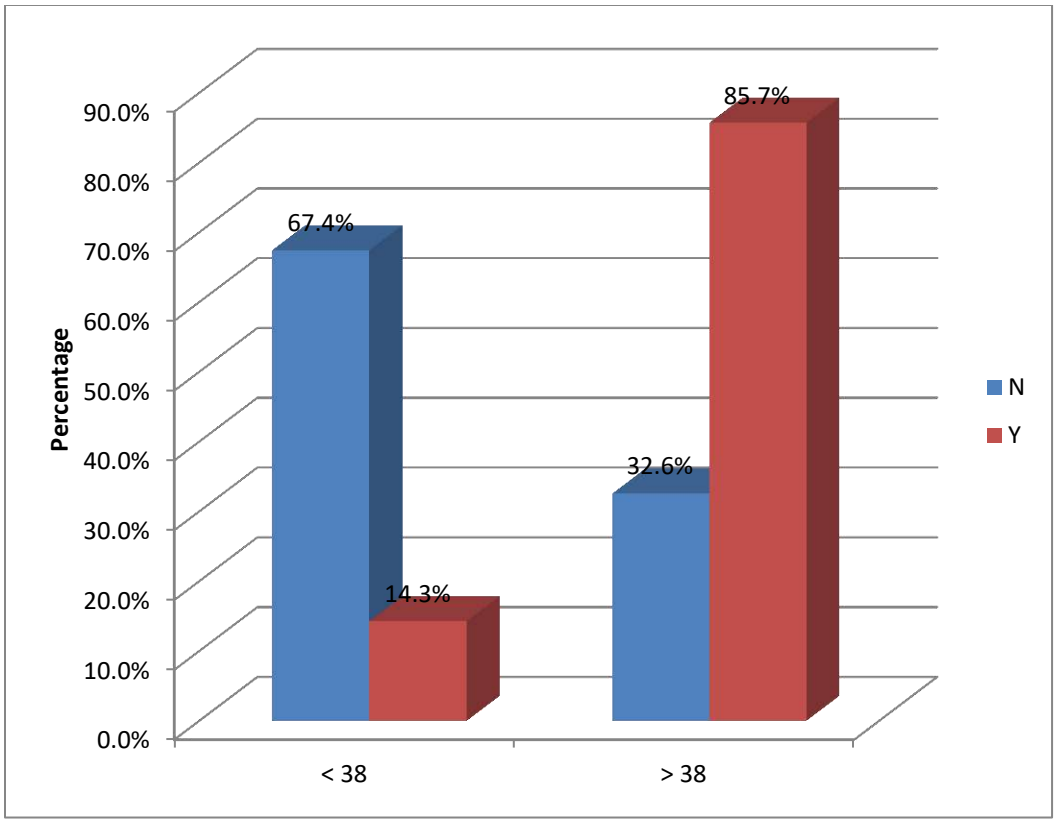

Figure 15: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 38%.

Table 19: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 38%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IVC collapsibility index	< 33	27	62.8%	0	0.0%	27	9.55	0.002
	> 33	16	37.2%	7	100.0%	23		
Total		43	100.0%	7	100.0%	50		

Table 20: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 33%

Statistic	**Value**	95% CI
Sensitivity	**85.71%**	42.13% to 99.64%
Specificity	**67.44%**	51.46% to 80.92%
Positive Likelihood Ratio	**2.63**	1.56 to 4.45
Negative Likelihood Ratio	**0.21**	0.03 to 1.32
Disease prevalence (*)	**14.00%**	5.82% to 26.74%
Positive Predictive Value (*)	**30.00%**	20.21% to 42.03%
Negative Predictive Value (*)	**96.67%**	82.36% to 99.45%
Accuracy (*)	**70.00%**	55.39% to 82.14%

Another IVCCI cutoff value of 33% predicted PSAH with sensitivity and specificity of 100% and 62.79% respectively, having a NPV of 100% and 68% accuracy (p value =0.002).

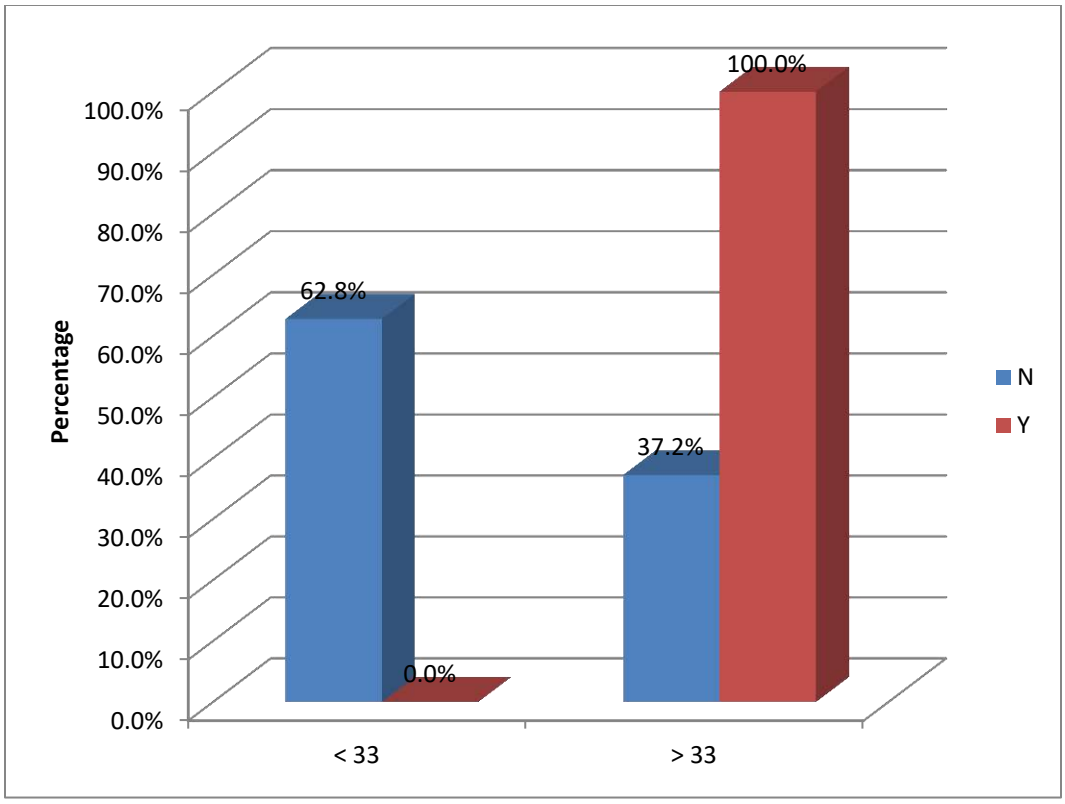

Figure 16: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 33%.

Table 21: CO-RELATION OF IVC COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 33%

Statistic	**Value**	95% CI
Sensitivity	**100.00%**	59.04% to 100.00%
Specificity	**62.79%**	46.73% to 77.02%
Positive Likelihood Ratio	**2.69**	1.82 to 3.96
Negative Likelihood Ratio	**0**	
Disease prevalence (*)	**14.00%**	5.82% to 26.74%
Positive Predictive Value (*)	**30.43%**	22.88% to 39.21%
Negative Predictive Value (*)	**100.00%**	
Accuracy (*)	**68.00%**	53.30% to 80.48%

Table 22: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 0º collapsibility index	< 30	23	53.5%	5	71.4%	28	0.786	0.375
	> 30	20	46.5%	2	28.6%	22		
Total		43	100.0%	7	100.0%	50		

A cut off value of 30% for IJVCI at 0º had sensitivity and specificity of 28.57% and 53.49% respectively, with NPV of 82.14%.

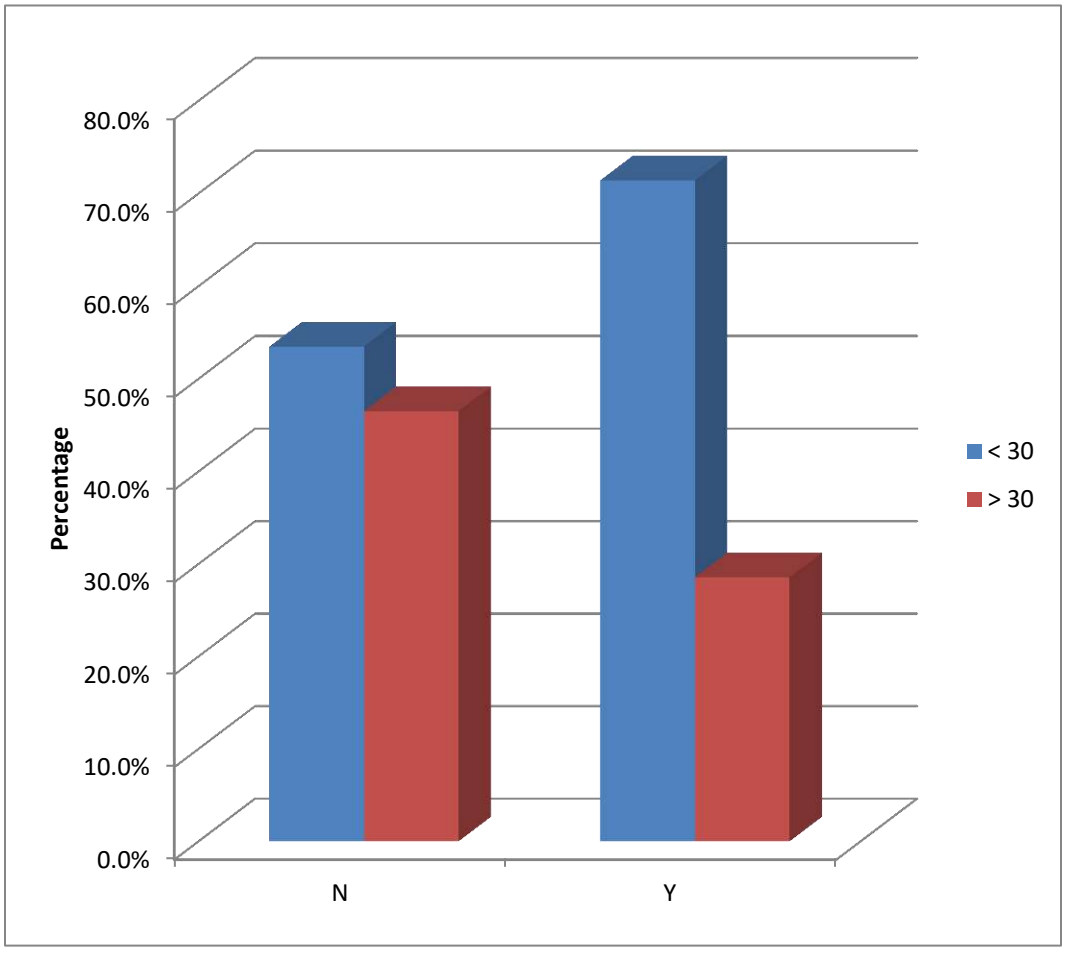

Figure 17: CO-RELATION OF IJV 0^0 COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%

Table 23: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%

Statistic	**Value**	95% CI
Sensitivity	**28.57%**	3.67% to 70.96%
Specificity	**53.49%**	37.65% to 68.82%
Positive Likelihood Ratio	**0.61**	0.18 to 2.07
Negative Likelihood Ratio	**1.34**	0.77 to 2.30
Disease prevalence (*)	**14.00%**	5.82% to 26.74%
Positive Predictive Value (*)	**9.09%**	2.88% to 25.20%
Negative Predictive Value (*)	**82.14%**	72.73% to 88.81%
Accuracy (*)	**50.00%**	35.53% to 64.47%

Table 24: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 0º collapsibility index	< 25	13	30.2%	1	14.3%	14	0.759	0.384
	> 25	30	69.8%	6	85.7%	36		
Total		43	100.0%	7	100.0%	50		

A cut off value of 25% for IJVCI at 0º had sensitivity and specificity of 85.71% and 30.23% respectively, with NPV of 92.86%.

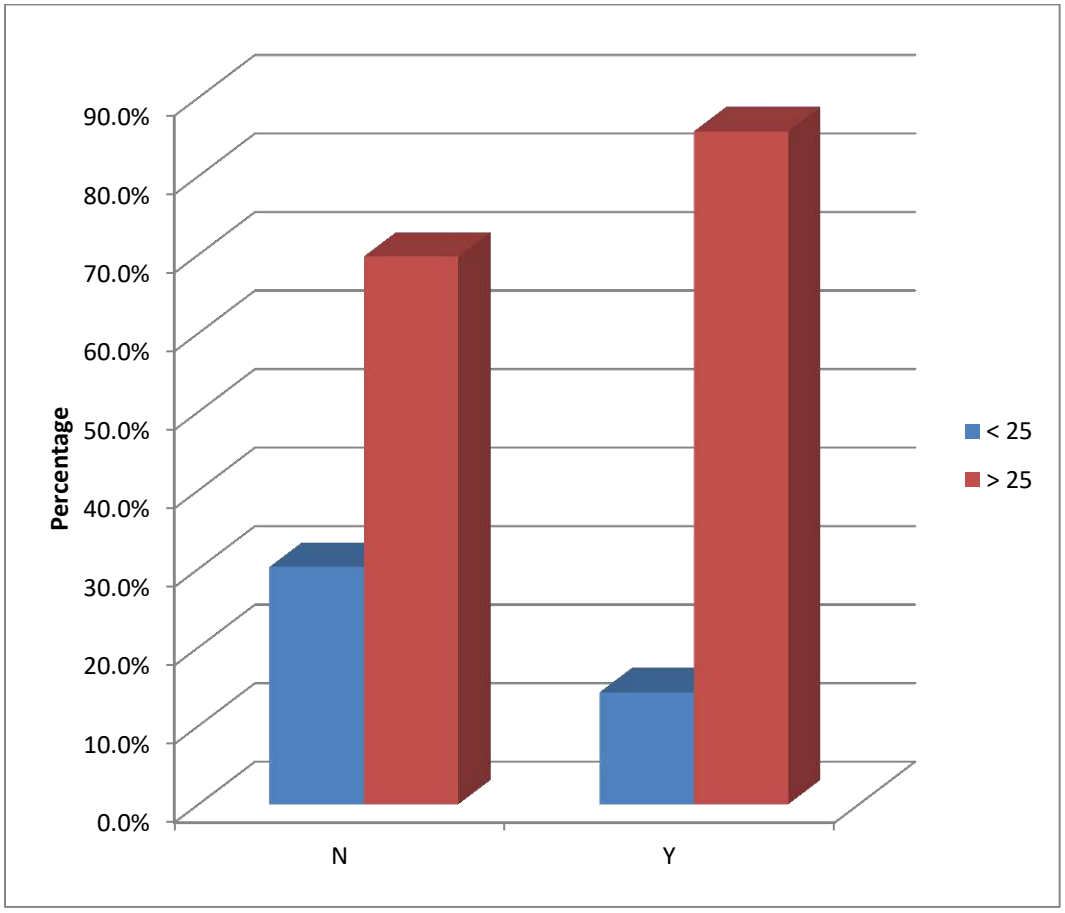

Figure 18: CO-RELATION OF IJV 0^0 COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

Table 25: CO-RELATION OF IJV 0º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

Statistic	Value	95% CI
Sensitivity	85.71%	42.13% to 99.64%
Specificity	30.23%	17.18% to 46.13%
Positive Likelihood Ratio	1.23	0.86 to 1.76
Negative Likelihood Ratio	0.47	0.07 to 3.07
Disease prevalence (*)	14.00%	5.82% to 26.74%
Positive Predictive Value (*)	16.67%	12.24% to 22.29%
Negative Predictive Value (*)	92.86%	66.69% to 98.83%
Accuracy (*)	38.00%	24.65% to 52.83%

Table 26: CO-RELATION OF IJV 30ºCOLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 30º collapsibility index	< 30	14	32.6%	3	42.9%	17	0.285	0.594
	> 30	29	67.4%	4	57.1%	33		
Total		43	100.0%	7	100.0 %	50		

For IJVCI at 30º, a cut off value of 30% had sensitivity and specificity of 57.14% and 32.56% respectively, with NPV of 82.35%.

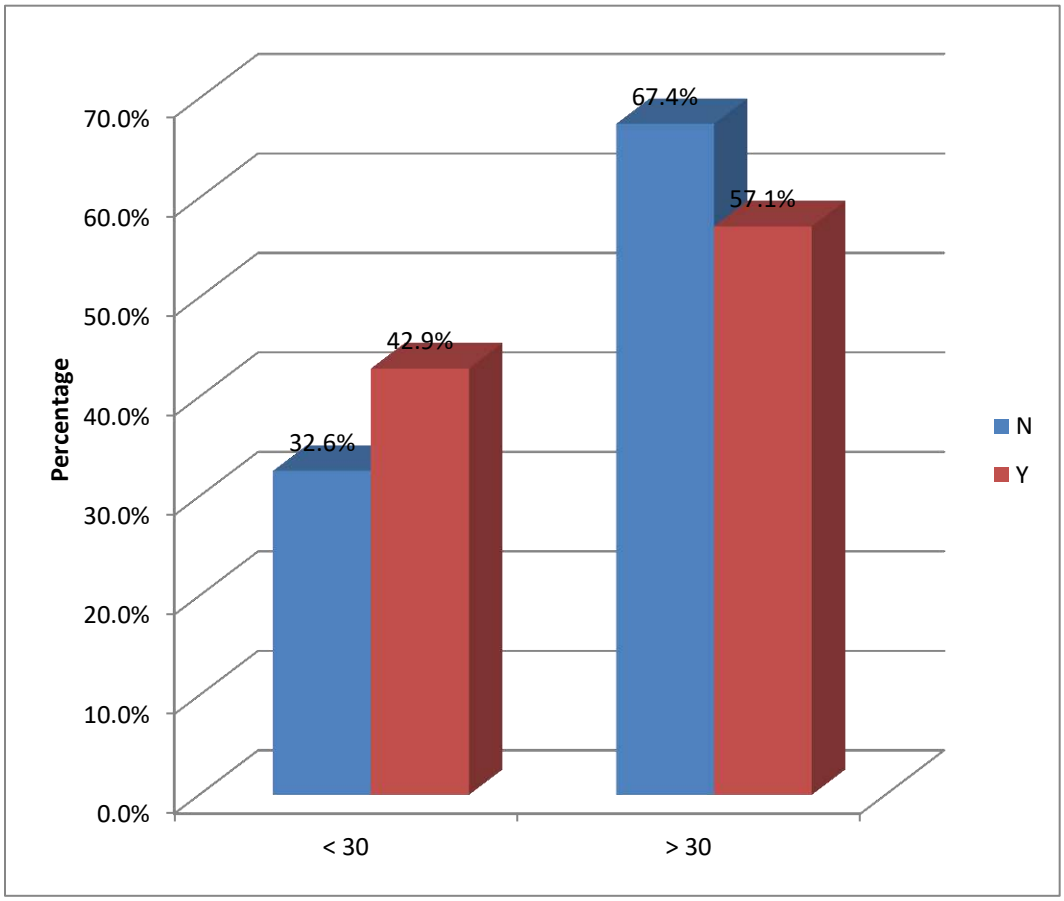

Figure 19: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%.

Table 27: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 30%

Statistic	Value	95% CI
Sensitivity	57.14%	18.41% to 90.10%
Specificity	32.56%	19.08% to 48.54%
Positive Likelihood Ratio	0.85	0.43 to 1.66
Negative Likelihood Ratio	1.32	0.51 to 3.43
Disease prevalence (*)	14.00%	5.82% to 26.74%
Positive Predictive Value (*)	12.12%	6.57% to 21.30%
Negative Predictive Value (*)	82.35%	64.17% to 92.40%
Accuracy (*)	36.00%	22.92% to 50.81%

Table 28: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

		Hypotension				Total	Chi-square value	p-value
		N		Y				
IJV 30º collapsibility index	< 25	12	27.9%	2	28.6%	14	0.001	0.971
	> 25	31	72.1%	5	71.4%	36		
Total		43	100.0%	7	100.0%	50		

A cut off value of 25% for IJVCI at 30º had sensitivity and specificity of 71.43% and 27.91% respectively, with NPV of 85.71%.

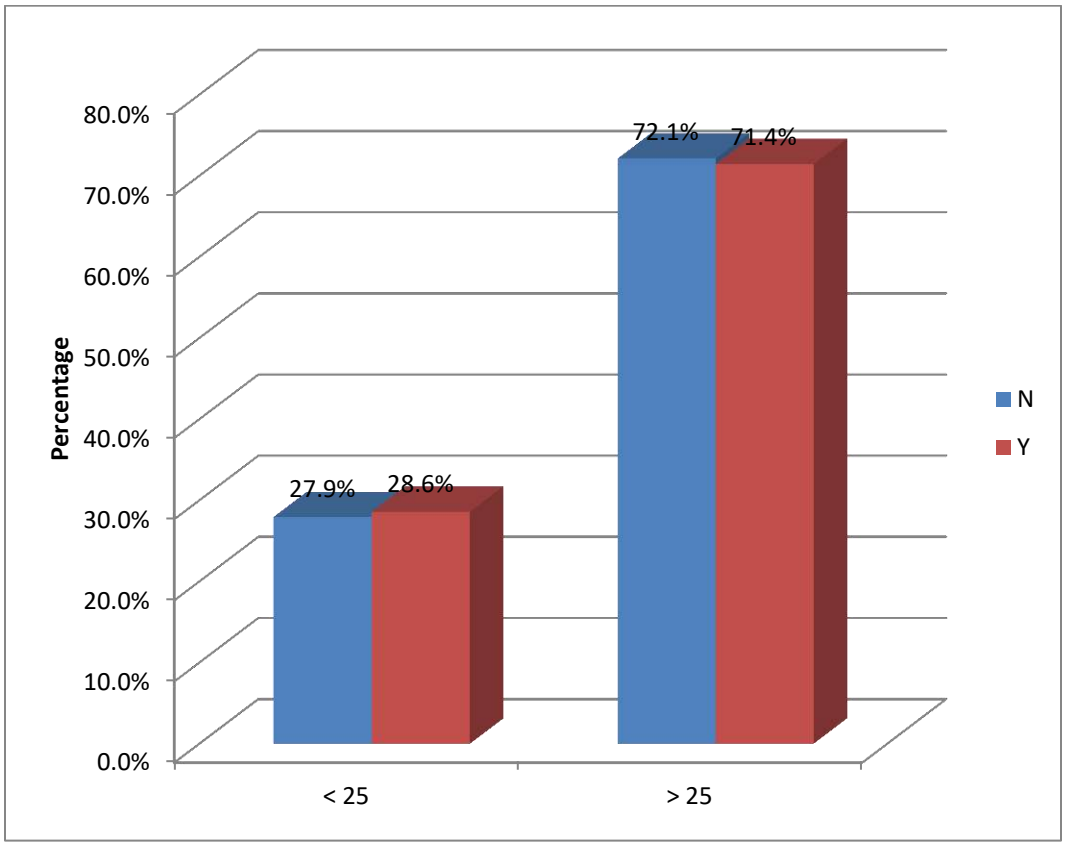

Figure 20: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

Table 29: CO-RELATION OF IJV 30º COLLAPSIBILITY INDEX WITH HYPOTENSION AT CUT OFF VALUE OF 25%

Statistic	**Value**	95% CI
Sensitivity	**71.43%**	29.04% to 96.33%
Specificity	**27.91%**	15.33% to 43.67%
Positive Likelihood Ratio	**0.99**	0.60 to 1.64
Negative Likelihood Ratio	**1.02**	0.29 to 3.63
Disease prevalence (*)	**14.00%**	5.82% to 26.74%
Positive Predictive Value (*)	**13.89%**	8.88% to 21.07%
Negative Predictive Value (*)	**85.71%**	62.85% to 95.51%
Accuracy (*)	**34.00%**	21.21% to 48.77%

Table 30: PARAMETERS OF PATIENTS HAVING HYPOTENSION

Hypotension	Percentage fall	IVC_IVC collapsibility index	IJV 0_IJV collapsibility index	IJV 30 collapsibility index
1	34.96	42	7	31
2	32.14	45	50	32
3	35.25	36	28	30
4	29.41	45	29	20
5	42.78	52	46	43
6	17.43	41	28	23
7	19.13	43	30	47

Maximum % of hypotension that occurred in a patient was 42.78%. The percentage fall in SBP correlated well with the IVCCI. Our criteria for hypotension was > 30% fall in systolic blood pressure (SBP) or SBP <90mm of Hg. Out of 7 patients who had hypotension, four patients had > 30% fall in systolic blood pressure (SBP) and three patients had SBP <90mm of Hg.

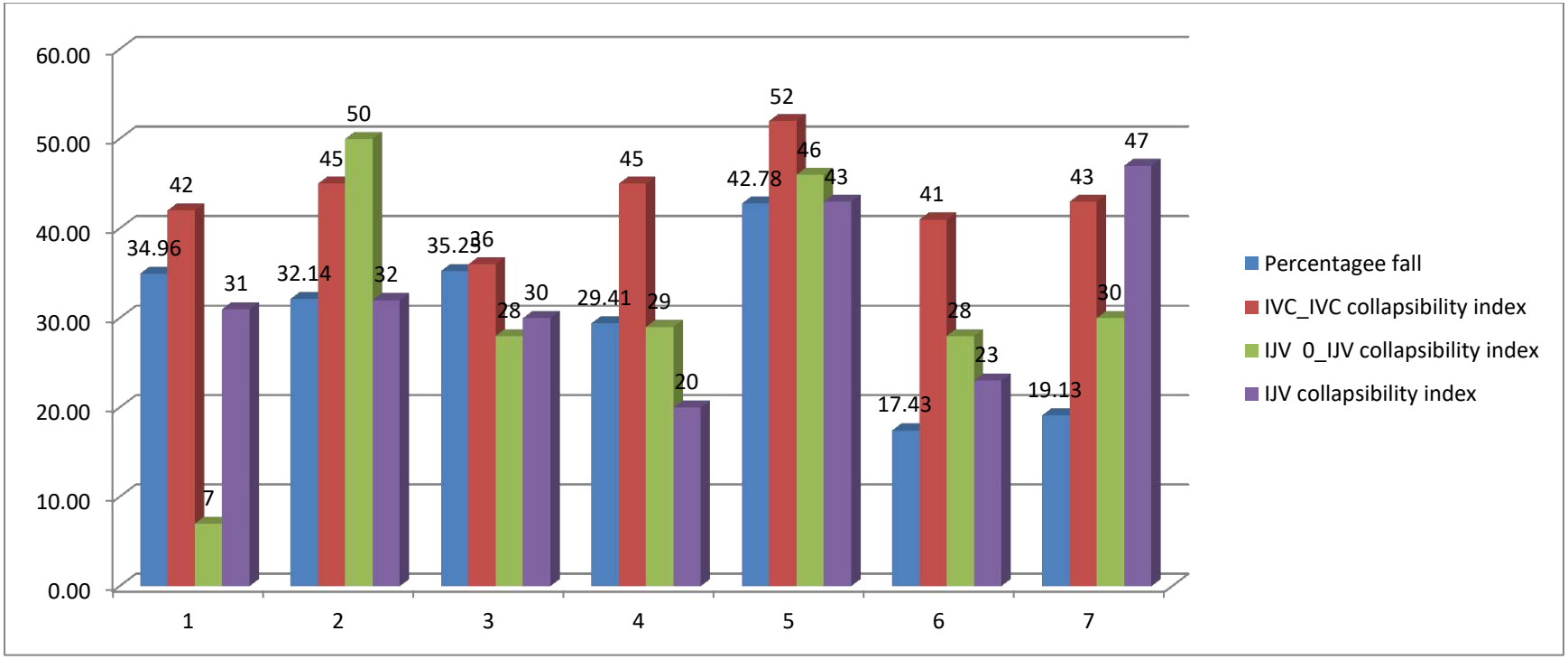

Figure 21: PARAMETERS OF PATIENTS HAVING HYPOTENSION

DISCUSSION

Keeping haemodynamic stability is essential for reducing the rate of postoperative complications in spinal anaesthesia. Intraoperative hypotension has a serious impact on myocardial injury, acute kidney injury, septic complications or the risk of 30-day and even one year mortality in selected patient populations after non-cardiac surgery [57]. Prevention of an undesired hypotensive event has a key role in providing patient safety. Monk et al showed in a retrospective analysis an association between intraoperative hypotension and 30-day postoperative mortality in non-cardiac surgery. They found that the incidence of death is 25% when the mean arterial pressure decreases more than 50%, for more than or equal to 5min [2]. Hypovolemia is the most common provoking factor of post inductional hypotension. The ability to predict which patients are at high risk of severe hypotension should enable anaesthetists to prepare and individualize treatment for such cases, from detrimental effects of hypotension. Monitoring based concept has been used for assessment of haemodynamic status of the patients. However, relying solely on heart rate, MAP, and central venous pressure as surrogate markers for blood flow to assess the haemodynamic status can be misleading sometimes [12]. Several invasive devices (e.g. pulmonary arterial catheter, PiCCO, Vigileo, etc.) are available for evaluating preload among other elements of hemodynamic status, but their universal use is not a reasonable option due to financial reasons, relatively high complication rate, known limitations and unnecessary invasiveness [58].

General physical health, concomitant comorbidities, fasting state, or medications used by patients can have an impact on the volume status [5]. Deficit in volume status can be attended by adequate fluid infusion either by preloading or by coloading [59]. Monitored fluid infusion is gaining more importance over blind fluid infusion to avoid complications and fluid overload [60]. Multiple studies have reported the usefulness of point-of-care ultrasound performed by anesthesiologists [7]. It has been reported that

ultrasonography measurements of the inferior vena cava (IVC) or internal jugular vein (IJV) diameter and collapsibility index can be used to determine the intravascular volume [47,50,52,53] .

IVC ultrasound is a non-invasive, quickly learned, and conducted approach that is often used to predict fluid responsiveness for guiding fluid treatment in intensive care. But, IVC visualization may not feasible in up to 15% of patients due to obesity, intra-abdominal gas distension, intra-abdominal masses, and surgical dressings [61, 62]. The measurement process of IJV parameters can be an easy alternative to IVC as it is readily accessible, and measurements are found to be equivalent in both right and left IJV [50]. It simply requires the skill to perform point-of-care ultrasound examination to identify the IJV, and measure the AP diameter during inspiration and expiration for calculating the collapsibility index.

In our study, we compared the efficacy of inferior vena cava collapsibility index (IVCCI) with internal jugular vein collapsibility index (IJVCI) to predict hypotension in spinal anaesthesia. The study was conducted in 50 patients, and incidence of hypotension was 14% (7/50). A few previous reports stated that the incidence of PSAH hypotension varied between 15-33% in different series [1]. The main reason for this discrepancy lies in the difference in the definition of hypotension between studies. In our study, hypotension n was defined as fall in systolic blood pressure (SBP) > 30% from the baseline or any episode of systolic pressure going below 90mm of Hg [5]. In a study by Elbadry et al in 55 pregnant females, PSAH was encountered in 26 cases (47.27% incidence). Another study by Singh et al, reported a high incidence, as PSAH was detected in 23 out of 40 included cases (57.5%) [26, 55]. However, both of these studies were in obstetric patients and hypotension was defined as decrease in MAP of more than 20% of its basal value or MAP 65 mmHg. Our criteria for hypotension was fall in SBP > 30% or SBP < 90mm of Hg, which may be the reason for lesser incidence of hypotension in our study.

We determined the IVCCI using ultrasound before spinal anesthesia and tried to predict hypotension with a cut-off value of 43% for IVCCI. In our study, IVCCI had a sensitivity and specificity of only 42.86% and 74.42% respectively, with NPV of 88.89% in prediction of PSAH. At cutoff value of >43%, IVCCI had a poor correlation with hypotension and our results were statistically insignificant (p value >0.05). This cutoff value (>43%) was adopted from study done by Zhang *et al*. in a systematic review where a total of eight studies involving 235 patients were analysed [5]. However, the cutoff values of IVCCI varied across studies ranging from 12 to 40% [27, 53, 55, 60]. In their study, Zhang *et al*. investigated the prediction of hypotension after induction of general anesthesia by preoperative IVCUS in a prospective study on 100 patients. After regression analysis, they found that IVCCI was an independent predictor of hypotension with odds ratio 1.17 (1.09–1.26). IVCCI was also positively associated with a percentage fall in MAP (regression coefficient, 0.27). They concluded that preoperative IVCCI measurement was a reliable predictor of hypotension after induction of general anaesthesia with a sensitivity of 78.6% and a specificity of 91.7% at a cutoff value of 43%. Purushothaman *et al*. also derived similar result with IVCCI cutoff 43% having high sensitivity of 86.67% and high specificity 94.2%. Both of these studies were on hypotension related to general anaesthesia [63]. Salama and Elkashlan *et al*. also derived that preoperative USG IVCCI measurement predicted PSAH, with IVCCI cutoff at 44.7% having high sensitivity of 84% and specificity of 77% [10].

Szabo *et al*. have studied the role of IVCCI in the prediction of hypotension associated with general anaesthesia in spontaneously breathing non cardiac surgical patients. They concluded that preoperatively detected IVCCI ≥50% can predict post induction hypotension with high specificity but low sensitivity. The selected 50% level of the IVCCI had a sensitivity of only 45.5% (95% CI 28.1-63.7%), but the specificity was high at 90.0% [64]. The criteria for hypotension was

similar to our study and sensitivity (42.86% in our study) for prediction of hypotension was also comparable.

Ting ting Ni and team showed that IVCCI had a sensitivity of 83.9%, a specificity of 76.3%, and a positive predictive value of 84% for predicting hypotension following spinal anaesthesia at a cut-off value of >42% [45]. In a recent study by Ayyanagouda et al, they concluded that ultrasound-guided IVC fluid optimisation before giving spinal anaesthesia led to 40% reduction in the incidence of PSAH [27]. Similar results were seen in a study done by Ceruti *et al* on 160 patients posted for surgeries under spinal anaesthesia [41]. They used trans-thoracic ultrasound with 3s probe and they showed 35% reduction in PSAH.

In our study we performed trans-abdominal ultrasound using curvilinear probe for IVC measurements at 3-4 cm from the right atrium. Our results and criteria for hypotension were similar to studies done by Pinsky *et al*. and Maciuliene *et al*. which proved that reduction in IVC diameters and increase in IVCCI do not predict hypotension and bradycardia during SA in spontaneously breathing patients undergoing elective knee joint replacement surgery [40]. They found that, even though BPs, MAP, and HR decrease after the beginning of SA, IVC inspiratory diameter, IVC expiratory diameter, or IVC-CI measurements did not change significantly at any time point. Furthermore, there was no correlation between changes in arterial blood pressure and HR to changes of IVC-CI. The SBP and HR in our study also, followed the same decreasing pattern after spinal anaesthesia. Incidence of hypotension was 25% in their study and it may be due to the drug dose in study by Macuiliene was 15-17mg of levobupivacaine, which was higher than our dose of 10mg (2ml) of bupivacaine [40].

Elbadry et al proved that for IVCCI, a cut-off point of 33% had sensitivity and specificity of 84.6 and 93.1% respectively, for predicting PSAH (>20% fall in MAP), with a diagnostic accuracy of 89.1%. Additionally, IJVCI had

sensitivity and specificity of 84.6 and 82.8%, respectively, for predicting the same complication using a cut-off value of 38.5% [55].

Considering the variability in cutoff value of IVCCI in different studies, we postulated to co-relate the efficacy of IVCCI in prediction of hypotension by lowering the cutoff value of IVCCI to 38% and 33% respectively.

At a cutoff value of 38%, IVCCI correlated well with spinal hypotension, and had a sensitivity and specificity of 85.71% and 67.44% respectively, with NPV of 96.67% and accuracy of 70% (p value =0.012).

Another IVCCI cutoff value of 33% predicted PSAH with sensitivity and specificity of 100% and 62.79% respectively, having a NPV of 100% and 68% accuracy (p value =0.002). So, when the IVCCI was taken as 33%, the correlation of all the 7 seven patients who had hypotension in our study, came out to be significant with p value < 0.05.

Therefore, we determined that IVCCI can be used as a predictor of post spinal hypotension at a cutoff value of 33%.

In our study, for IJV collapsibility index (IJVCI) at 0º, a cut off value of 39% had sensitivity and specificity of 28.57% and 83.72% respectively, with NPV of 87.80% for PSAH prediction. IJVCI at 30º head elevation and at same cutoff value of 39% had sensitivity and specificity of 28.57% and 58.14% respectively, along with NPV of 83.33%. Although, our study had a high negative predictive value, yet all the results for IJVCI (0º and 30º) at a cut off value of 39%, were not having statistical significance (p value >0.05).

Elbadry used a similar cutoff value of 38.5% for IJVCI, but their sensitivity and specificity was 84.6 and 82.8%, respectively, in predicting PSAH. Our study was different from them as they conducted the study in 55 pregnant females and 26 patients had intraoperative hypotension (47% incidence) as compared to only 14% incidence in our study. The obstetric patients have more susceptibility to hypotension after spinal anaesthesia as gravid uterus results in aorto caval compression, resulting in further decrease in venous return after sympatholysis and vasodilation. Moreover, the criteria

for hypotension was lower (> 20% fall in MAP) as compared to our study (> 30% fall in SBP).

Ahmed Elasyed Ibrahim et al carried out a study on 67 patients of both sexes for the bedside assessment of central venous pressure/fluid status in critical ill intensive care unit patients. There were a statistically significant decrease in all CI (Collapsibility indices) among cases had CVP > 10 mmHg compared to cases had CVP ≤ 10. CI of IJV at 0º at cut off > 21.4 had sensitivity 88.4%, specificity 79.2% and accuracy 85.1% in prediction of CVP ≤ 10 while at 30º at cut off 20.7 had sensitivity 90.7%, specificity 83.3% and accuracy 88.1% in prediction of CVP ≤ 10 mmHg [52]. Similarly, Killu et al. reported that IJVCI more than 39% had sensitivity and specificity of 87.5 and 100%, respectively, in predicting hypovolemia in critically ill patients [33].Their study was designed to determine the correlation between clinical volume status and IJV collapsibility index. The study was not designed to replace invasive monitoring in ICU patients, rather to determine if the IJV collapsibility index was a promising adjunct to other parameters including invasive CVP monitoring, given the limitation and time required in obtaining central venous access.

Haliloglu et al. reported that IJVCI more than 36% had sensitivity and specificity of 78% and 85% respectively, in predicting hypovolemia in sepsis [35]. The difference in statistical values of above studies from our study may be due to higher susceptibility of critically ill and septic patients to hypotension. Meanwhile, the patients in our study were posted for elective surgeries and they were haemodynamically stable. So, the IJVCI in our study did not show any significant positive correlation with hypotension after spinal anaesthesia.

Bassant et al reported an incidence of 66.2% hypotension after spinal anaesthesia in a study of 71 elderly patients, keeping a cutoff value of 34.4% for IJVCI. The sensitivity and specificity was 62.7% and 79.17% respectively, with PPV of 85.3% [51]. Kilic et al (2020) included 47 patients and the analysis showed that IJV collapsibility index had a sensitivity of

64% and a specificity of 63.6% to predict the post spinal hypotension at a cut-off point of 22.6% [6]. According to the previous studies, whenever IJVCI was used as a predictive tool in operating rooms, its predictive ability for hypotension was just moderate. Our study also resulted in poor correlation of IJVCI with hypotension.

We planned to compare our results by hypothesizing the cutoff value of IJVCI used in different previous studies. Therefore, when a cut off value of 30% was taken for IJVCI at 0º, it had sensitivity and specificity of 28.57% and 53.49% respectively, with NPV of 82.14% and a cut off value of 25% for IJVCI at 0º had sensitivity and specificity of 85.71% and 30.23% respectively, with NPV of 92.86%.

For IJVCI at 30º head elevation, a cut off value of 30% had sensitivity and specificity of 57.14% and 32.56% respectively, with NPV of 82.35% and a cut off value of 25% for IJVCI at 30º had sensitivity and specificity of 71.43% and 27.91% respectively, with NPV of 85.71%. In our study, at a cutoff of 25%, the sensitivity of IJVCI at 0º and 30º head elevation increased to 85.71% and 71.43% respectively. The predictive ability of IJVCI was moderate at 25% cutoff, though we did not get a significant correlation at any cutoff value of IJVCI (39%, 30%, 25%).

Our study had a few limitations. It was an observational analysis done at a single institution. There was potential selection bias on the limited convenient sample enrolled. Ultrasound is an operator dependent technique: even if all IVCUS examinations have been performed by a very small and homogeneous group of anaesthesiologists, specifically trained for this trial and with a solid clinical experience, a possible impact on the results for some inter individual differences in the performance of the technique cannot be excluded. Another limitation is the fact that we did not measure the IVC in the post spinal period. Moreover, contrary to Zhang et al, we had spontaneously breathing patients. The incidence of hypotension was just 14% and there were a few factors attributing to such low incidence of post spinal hypotension in our study like, patients were

mostly ASA I (50%) young adults, total drug dose was only 2.5ml which was comparatively lesser, to cause severe hypotension. Most of our cases were urological procedures, in lithotomy position and venous return to the heart improved in that position. Furthermore, there is a usage of plenty of irrigation fluids in urological surgeries like TURP, which also add on to increased fluid volume in the patients. Lastly, our criteria for hypotension had a higher threshold value of > 30% fall in SBP.

Although our results for both IVCCI and IJVCI were not statistically significant at proposed cutoff values of >43% and >39% respectively, yet IVCCI was a better parameter than IJVCI in prediction of hypotension. Lowering the cutoff values for both IVCCI and IJVCI helped in improving the sensitivity of our study. IVCCI gave 100% sensitivity at cutoff value of 33% and came out to be a good parameter in pre-operative prediction of spinal hypotension. Therefore, IVC can be readily used in operative areas to prevent unwanted and dangerous complication of PSAH, thereby reducing the morbidity and mortality.

Considering the results of previous studies and our study, we postulated that IJVCI can be a useful predictor of hypovolemia only in critically ill patients and its role in predicting spinal hypotension in elective surgeries is not significant.

SUMMARY AND CONCLUSION

The present study was conducted in the Department of Anaesthesiology, Dayanand Medical College and Hospital, Ludhiana after getting approval from the institutional ethical committee. The aim of the study was to compare the efficacy of inferior vena cava collapsibility index (IVCCI) with internal jugular vein collapsibility index (IJVCI) for prediction of post spinal hypotension.

A total number of 50 patients belonging to ASA I, II and III grade, scheduled to undergo an elective surgery in spinal anaesthesia were enrolled in our study. Both IVCCI and IJVCI were calculated before spinal anaesthesia, using ultrasound in all the patients. Hypotension was defined as > 30% fall in systolic blood pressure or SBP < 90mm of Hg, and it occurred in 7 out of 50 patients. The predictive ability of IVCCI and IJVCI was measured using cut off values of 43% and 39%, respectively. We obtained statistically insignificant results at our pre-decided cut off values of IVCCI and IJVCCI. However, when we lowered these cut off values, the sensitivity of our results improved grossly and IVCCI at 33% cutoff, had 100% sensitivity in predicting hypotension. But, predictive ability of IJVCI still remained questionable in our study.

Consequently, IVCCI assessment prior to spinal anaesthesia assists in predicting the likelihood of post spinal anaesthesia hypotension, thus, giving us an opportunity ito optimize patients' volaemic status and hence, reducing the incidence and severity of morbidity and mortality associated with post spinal hypotension. Following clinical interpretation of our findings, we came to the conclusion that IJVCI assessment can not be used as an universal method for identifying individuals at risk for development of hypotension post spinal anaesthesia but, it may be used as an adjunct in specific group of patients where IVCCI calculation is not possible/technically difficult. Hence, we encourage the pre-operative use of ultrasound to calculate inferior vena cava collapsibility index (IVCCI),

which can successfully predict risk of hypotension after spinal anaesthesia in susceptible individuals.

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Sr. No	MRD. No	INITIALS	Date of surgery	Age	Sex	ASA Grade	Weight (Kg)	Height	BMI (Kg/m2)	Drug allergy	Past History	Pulse rate	SpO2	SBP	DBP	Respiratory rate	Cns Examination	Chest Examination	CVS Examination	IVC_Maximum diameter (cm)	IVC_Minimum diameter (cm)	IVC_IVC collapsibility index	IVC_IVC collapsibility index gp	IJV 0_Maximum diameter (cm)
1	1131008	RK	07/10/2021	47	M	I	72	5'7"	24.9	NKDA	-	61	100	118	80	14	conscious,oriented	B/l clear NVBS	S1,S2 present	2.27	2.21	3	0	0.69
2	1133412	RD	13/07/2021	40	M	II	86	5'11"	26.5	NKDA	-	66	98	120	80	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.57	1.31	16	0	0.69
3	1148511	RL	27/08/2021	82	M	II	64	5'9"	20.9	NKDA	HTN	86	98	170	100	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.92	1.41	26	0	1.16
4	1157630	SS	28/08/2021	20	M	I	75	5'10"	23.7	NKDA	-	86	98	130	70	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.76	1.32	25	0	0.64
5	1163282	I	30/08/2021	30	M	I	66	5'6"	23.7	NKDA	-	100	99	110	70	18	conscious,oriented	B/l clear NVBS	S1,S2 present	1.51	1.13	25	0	0.95
6	937953	NK	21/10/2021	58	F	III	64	5'2"	26	NKDA	HTN, DM	82	99	130	72	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.9	1.1	42	0	0.56
7	1156161	TS	22/10/2021	19	M	I	56	5'9"	18.3	NKDA	-	78	100	120	78	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.76	0.88	50	1	0.54
8	1166498	VK	22/10/2021	28	M	I	69	5'7"	23.8	NKDA	-	90	100	122	76	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.26	1.05	16	0	0.8
9	1206053	VS	17/10/2021	32	M	III	45	5'6"	16.1	NKDA	CKD	82	100	140	76	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.39	0.69	50	1	0.8
10	80881	JS	26/11/2021	40	M	I	74	5'8"	25	NKDA	-	70	100	136	72	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.45	0.86	41	0	1.2
11	896483	NS	27/11/2021	66	M	II	42	5'4"	16	NKDA	HTN	107	99	136	74	18	conscious,oriented	B/l clear NVBS	S1,S2 present	1	0.55	45	1	1.04
12	126108	SS	30/11/2021	43	M	I	71	5'8"	24	NKDA	-	78	100	126	74	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.65	1.23	25	0	0.9
13	1186289	RK	12/01/2021	60	M	II	50	5'5"	18.4	NKDA	HTN	68	98	144	76	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.41	0.92	35	0	1.2
14	1216924	CG	12/02/2021	24	M	I	68	5'8"	23	NKDA	-	89	100	142	81	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.65	0.86	48	1	1.3
15	1203914	GS	12/03/2021	60	M	I	72	5'6"	25.8	NKDA	-	68	100	148	82	15	conscious,oriented	B/l clear NVBS	S1,S2 present	2.92	2.5	14	0	1.68
16	1213043	HS	12/03/2021	75	M	II	62	5'7"	21.5	NKDA	HTN	75	99	142	94	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.96	1.59	19	0	1.16
17	1217569	P	12/04/2021	26	F	I	43	5'3"	16.8	NKDA	-	98	100	110	70	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.59	0.67	58	1	0.54
18	850548	RR	12/07/2021	39	M	I	75	5'9"	24.5	NKDA	-	106	100	132	80	16	conscious,oriented	B/l clear NVBS	S1,S2 present	2.02	1.04	48	1	0.93
19	145203	RB	12/08/2021	60	M	III	71	5'8"	24	NKDA	HTN, DM	80	98	146	68	18	conscious,oriented	B/l clear NVBS	S1,S2 present	1.38	0.85	38	0	0.65
20	1220946	YM	12/10/2021	46	M	I	72	5'10"	22.7	NKDA	-	70	100	120	70	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.29	0.61	52	1	1.03
21	1226095	SS	27/12/2021	50	F	III	65	5'1"	27.1	NKDA	HTN, DM, CKD	110	95	160	94	18	conscious,oriented	B/l clear NVBS	S1,S2 present	1.38	0.71	48	1	1.01
22	880453	CS	02/10/2022	34	F	I	80	5'11'	24.7	NKDA	-	90	100	120	70	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.42	1.05	26	0	1.04
23	1250175	IS	02/11/2022	80	M	II	80	6'00''	23.9	NKDA	HTN	76	100	180	79	14	conscious,oriented	B/l clear NVBS	S1,S2 present	0.76	0.53	30	0	1.38
24	1159595	BS	25/02/2022	29	M	I	64	5'7"	22.1	NKDA	-	69	100	126	65	12	conscious,oriented	B/l clear NVBS	S1,S2 present	0.63	0.55	13	0	1.08
25	1263860	JK	03/05/2022	70	M	III	40	5'1"	16.7	NKDA	HTN, CAD	95	97	180	92	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.91	1.71	10	0	0.92
26	1279780	SS	04/01/2022	68	M	II	64	5'7"	22.1	NKDA	HTN	66	99	154	78	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.26	0.76	39	0	0.81
27	1278965	KS	04/02/2022	68	M	III	55	5'8"	18.6	NKDA	CAD, DM	96	99	136	84	16	conscious,oriented	B/l clear NVBS	S1,S2 present	0.61	0.39	36	0	1.21
28	851329	SN	04/12/2022	64	M	II	45	5'6"	15.9	NKDA	DM	76	100	128	64	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.26	0.39	69	1	0.75
29	1286866	JS	14/04/2022	19	M	I	58	5'10"	18.3	NKDA	-	59	100	110	60	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.5	1.03	30	0	0.51
30	1288163	SS	16/04/2022	65	M	III	70	5'10"	22.3	NKDA	HTN, CAD	74	100	160	92	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.58	1.42	10	0	1.4
31	1288805	TS	19/04/2022	65	M	I	80	5'8"	26.7	NKDA	-	78	100	142	76	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.63	0.96	41	0	0.73
32	465933	LS	20/04/2022	79	M	II	75	5'10"	23.7	NKDA	HTN	63	100	156	82	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.51	1.06	30	0	1.28
33	205995	YL	20/04/2022	81	M	III	45	5'4"	17.1	NKDA	HTN, CAD, DM	59	100	164	86	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.07	0.95	11	0	0.72
34	1251105	CS	20/04/2022	49	M	I	76	5'7"	26.3	NKDA	-	71	100	134	79	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.39	1.13	19	0	1.05
35	172912	VS	21/04/2022	79	M	III	66	5'8"	22.3	NKDA	CAD	82	100	132	74	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.26	0.69	45	1	0.9
36	1294393	SS	29/04/2022	45	M	II	68	5'6"	24.4	NKDA	-	62	100	128	75	14	conscious,oriented	B/l clear NVBS	S1,S2 present	1.87	1.36	27	0	0.75
37	5465	SK	07/04/2022	45	M	II	76	5'10"	24.3	NKDA	DM	80	100	120	70	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.7	1.27	25	0	0.64
38	1333223	SK	07/04/2022	54	M	II	91	5'9"	29.7	NKDA	DM	74	100	154	68	16	conscious,oriented	B/l clear NVBS	S1,S2 present	2.29	1.7	26	0	1.12
39	1257225	SC	07/06/2022	82	M	III	82	5'7"	21	NKDA	DM, HTN	78	97	182	94	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.78	0.85	52	1	1.51
40	1079975	BS	26/07/2022	50	M	II	87	5'11"	27.5	NKDA	-	76	100	128	72	15	conscious,oriented	B/l clear NVBS	S1,S2 present	0.82	0.32	61	1	1.6
41	1343374	T	26/07/2022	45	M	I	56	5'10"	17.9	NKDA	-	70	100	120	62	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.63	0.96	41	0	1.07
42	1360206	MK	19/08/2022	55	F	II	67	5'3"	26.2	NKDA	HTN	83	99	154	88	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.37	0.58	57	1	1.21
43	1362436	VA	19/08/2022	23	M	I	72	5'8"	24.1	NKDA	-	79	100	122	66	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.68	1.23	27	0	1.16
44	1361325	GS	19/08/2022	58	M	I	82	5'10"	25.9	NKDA	-	92	100	143	75	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.12	0.77	31	0	0.91
45	1361991	PK	22/08/2022	45	F	I	61	5'3"	23.8	NKDA	-	67	100	112	63	15	conscious,oriented	B/l clear NVBS	S1,S2 present	1.33	0.75	43	0	1.18
46	1358680	RK	23/08/2022	34	M	I	59	5'5"	21.7	NKDA	-	73	100	129	74	16	conscious,oriented	B/l clear NVBS	S1,S2 present	0.93	0.77	17	0	1.26
47	1364713	JS	23/08/2022	34	M	I	75	5'10"	23.7	NKDA	-	81	100	132	73	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.43	1.17	18	0	1.29
48	1181081	PG	25/08/2022	46	M	I	80	5'6"	28.7	NKDA	-	87	99	145	81	17	conscious,oriented	B/l clear NVBS	S1,S2 present	0.88	0.49	44	1	0.76
49	1366346	MB	26/08/2022	58	M	II	81	5'9"	26.4	NKDA	-	102	100	139	76	16	conscious,oriented	B/l clear NVBS	S1,S2 present	1.51	1.18	22	0	0.98
50	1331830	VS	29/08/2022	18	M	I	55	5'8"	18.4	NKDA	-	71	100	126	71	15	conscious,oriented	B/l clear NVBS	S1,S2 present	0.81	0.57	30	0	0.75

Sr. No	MRD. No	IJV 0_Minimum diameter (cm)	IJV 0_IJV collapsibility index	IJV 30_Maximum diameter (cm)	IJV 30_Minimum diameter (cm)	IJV collapsibility index	Highest level of sensory block achieved	Time taken to achieve highest level of sensory block (MINS)	Highest degree of motor block achieved	Time taken to achieve highest degree of motor block (MINS)	HR_Baseline	HR_0 Minute	HR_1 Minute	HR_2 Minute	HR_3 Minute	HR_4 Minute	HR_5 Minute
1	1131008	0.67	2.9	0.57	0.34	40	T6	20	MB3	6	61	60	61	59	61	64	65
2	1133412	0.49	29	0.48	0.36	25	T6	21	MB3	5	80	76	78	72	74	74	72
3	1148511	0.95	18	1.38	1.32	4	T6	20	MB3	6	86	84	85	80	70	86	90
4	1157630	0.29	54	0.45	0.28	38	T8	19	MB3	7	112	98	95	91	84	88	86
5	1163282	0.79	17	1	0.58	42	T6	23	MB3	6	117	75	81	95	96	97	98
6	937953	0.52	7	0.38	0.26	31	T6	20	MB3	4	84	84	86	89	92	89	87
7	1156161	0.33	39	0.55	0.29	47	T6	21	MB3	6	84	72	92	95	79	88	101
8	1166498	0.39	51	0.53	0.28	47	T6	19	MB3	5	84	94	95	96	93	98	90
9	1206053	0.6	25	0.37	0.25	32	T8	20	MB3	8	78	86	76	82	80	80	83
10	80881	0.98	18	0.76	0.61	19	T6	20	MB3	7	73	82	84	84	92	89	92
11	896483	0.52	50	0.53	0.36	32	T6	19	MB3	5	100	106	113	108	113	113	111
12	126108	0.55	39	0.56	0.26	53	T8	19	MB3	7	73	80	86	80	90	91	89
13	1186289	0.83	31	0.73	0.48	34	T6	20	MB3	7	70	70	71	72	71	72	71
14	1216924	0.95	27	0.78	0.33	57	T8	23	MB3	10	91	87	84	104	80	77	74
15	1203914	1.45	14	1.5	1.2	20	T6	21	MB3	8	60	62	64	59	60	61	59
16	1213043	0.6	48	1.06	0.38	64	T8	21	MB3	8	76	73	74	76	75	75	74
17	1217569	0.3	44	0.49	0.3	39	T6	19	MB3	6	109	108	105	108	110	109	104
18	850548	0.73	21	1.14	1.01	11	T6	20	MB3	4	105	105	110	109	103	92	94
19	145203	0.25	61	0.64	0.35	45	T8	19	MB3	6	81	85	84	83	89	88	88
20	1220946	0.64	38	0.97	0.35	64	T6	20	MB3	7	67	70	66	65	70	68	62
21	1226095	0.74	27	1.16	0.44	62	T8	21	MB3	5	118	118	114	112	113	112	105
22	880453	0.69	33	0.5	0.35	30	T6	19	MB3	5	101	100	88	82	80	85	84
23	1250175	1.25	9	0.98	0.78	20	T6	21	MB3	7	74	68	70	71	68	69	66
24	1159595	0.79	26	0.91	0.55	39	T6	20	MB3	6	80	86	95	83	78	71	76
25	1263860	0.67	27	0.77	0.47	39	T6	19	MB3	5	98	94	95	93	95	95	95
26	1279780	0.55	32	0.37	0.17	54	T6	20	MB3	5	76	77	78	86	82	81	81
27	1278965	0.87	28	1.02	0.71	30	T6	19	MB3	5	100	101	105	103	102	102	101
28	851329	0.53	29	0.55	0.27	50	T6	18	MB3	5	89	90	93	93	93	92	91
29	1286866	0.24	53	0.42	0.28	33	T6	20	MB3	6	66	68	68	66	61	60	51
30	1288163	0.9	35	0.89	0.77	13	T6	20	MB3	6	74	72	70	73	71	74	69
31	1288805	0.37	49	0.62	0.18	70	T6	19	MB3	5	81	77	80	76	78	79	76
32	465933	1.06	17	1.11	0.86	22	T6	20	MB3	6	59	68	66	65	63	62	60
33	205995	0.51	29	0.63	0.41	35	T6	21	MB3	7	66	62	64	60	53	101	100
34	1251105	0.68	35	1.03	0.77	25	T6	19	MB3	6	77	78	70	82	84	88	88
35	172912	0.73	29	1.16	0.92	20	T6	19	MB3	6	88	100	94	91	92	87	88
36	1294393	0.5	33	0.54	0.25	53	T6	20	MB3	5	62	65	63	64	65	65	62
37	5465	0.4	37	0.22	0.15	31	T6	19	MB3	5	87	85	86	85	78	83	79
38	1333223	0.95	15	1.02	0.82	19	T6	20	MB3	6	70	71	75	68	72	65	65
39	1257225	0.82	46	1.24	0.71	43	T6	19	MB3	5	79	76	75	73	73	70	68
40	1079975	1.44	10	0.91	0.61	33	T6	21	MB3	7	75	75	71	70	67	59	67
41	1343374	0.77	28	0.83	0.64	23	T6	20	MB3	6	73	73	70	68	66	65	63
42	1360206	0.87	28	0.93	0.61	34	T6	19	MB3	5	85	86	84	81	83	84	82
43	1362436	0.83	28	0.92	0.76	17	T6	20	MB3	6	78	79	77	78	77	76	78
44	1361325	0.63	31	0.73	0.42	42	T6	21	MB3	6	90	90	88	89	86	87	87
45	1361991	0.82	30	0.97	0.51	47	T6	19	MB3	5	67	64	66	64	65	63	64
46	1358680	1.01	20	0.89	0.62	30	T6	19	MB3	5	76	73	73	71	74	72	71
47	1364713	1.02	21	1.16	0.95	18	T6	21	MB3	6	81	82	80	81	81	79	80
48	1181081	0.52	31	0.63	0.32	49	T6	19	MB3	6	90	91	88	90	89	86	87
49	1366346	0.72	26	0.83	0.49	41	T6	20	MB3	6	100	102	99	100	97	95	97
50	1331830	0.52	31	0.63	0.36	42	T6	19	MB3	5	73	71	72	70	67	68	70

Sr. No	MRD. No	HR_6 Minute	HR_7 Minute	HR_8 Minute	HR_9 Minute	HR_10 Minute	HR_12 Minute	HR_14 Minute	HR_16 Minute	HR_18 Minute	HR_20 Minute	HR_22 Minute	HR_24 Minute	HR_26 Minute	HR_28 Minute	HR_30 Minute	SBP_Baseline	SBP_0 Minute	SBP_1 Minute	SBP_2 Minute	SBP_3 Minute	SBP_4 Minute	SBP_5 Minute	SBP_6 Minute	SBP_7 Minute	SBP_8 Minute	SBP_9 Minute	SBP_10 Minute	SBP_12 Minute	SBP_14 Minute	SBP_16 Minute
1	1131008	66	67	60	62	60	59	60	60	59	61	63	62	62	60	59	118	112	109	105	97	106	108	105	102	100	98	103	98	98	97
2	1133412	72	70	68	70	69	68	64	66	67	67	64	67	61	64	63	142	120	117	120	118	117	117	118	113	114	117	115	113	113	118
3	1148511	84	81	82	84	87	84	84	82	83	81	80	78	76	76	76	170	164	152	147	138	140	148	132	129	127	120	116	119	110	108
4	1157630	74	85	77	76	75	70	74	72	77	73	75	74	72	73	74	140	130	129	125	123	123	117	119	126	22	116	125	117	127	130
5	1163282	100	110	113	107	103	103	101	98	104	107	110	104	103	104	102	110	100	117	105	113	110	116	111	113	124	115	113	111	110	112
6	937953	88	86	84	84	86	85	84	82	81	79	82	78	78	82	79	123	119	116	80	108	100	90	88	88	100	98	94	86	80	90
7	1156161	105	106	102	99	83	84	97	95	92	94	86	87	88	86	86	120	123	118	116	122	122	110	140	120	105	101	106	104	106	105
8	1166498	92	88	87	84	81	78	74	75	71	73	71	66	70	68	68	104	108	113	116	109	114	110	108	105	107	105	106	112	111	112
9	1206053	92	84	86	84	81	76	78	76	75	77	74	77	74	73	72	134	137	135	138	130	121	129	134	139	129	130	129	132	129	135
10	80881	82	94	93	92	90	92	85	96	89	80	80	84	83	75	82	130	146	148	138	125	130	127	122	123	124	124	122	120	128	119
11	896483	106	110	106	103	91	102	104	117	108	94	113	124	117	116	123	140	120	120	112	120	107	116	115	117	115	110	112	110	114	112
12	126108	86	87	82	80	76	78	77	80	76	76	73	72	72	72	71	123	128	133	121	119	123	121	118	118	115	114	111	114	114	115
13	1186289	68	67	65	66	64	64	59	61	62	59	63	60	61	64	61	150	176	161	154	155	153	150	147	146	139	137	136	130	131	127
14	1216924	81	80	71	73	77	73	70	68	72	71	64	59	65	63	71	146	141	136	148	141	144	142	143	144	141	135	139	137	137	138
15	1203914	59	55	88	86	83	85	80	84	81	83	83	80	82	81	82	160	158	155	158	139	136	138	131	128	126	131	127	128	122	131
16	1213043	76	74	75	73	72	71	73	71	71	67	62	64	65	65	63	148	152	149	154	151	148	150	144	140	136	135	131	128	122	117
17	1217569	108	104	109	110	106	108	105	101	106	100	99	97	95	95	91	118	115	110	110	112	107	114	112	106	111	106	106	112	115	115
18	850548	93	92	94	93	95	96	94	100	92	100	98	100	101	98	96	128	131	134	130	97	103	102	101	105	107	106	108	112	117	121
19	145203	87	88	87	87	85	86	83	77	79	80	75	79	78	77	73	139	143	152	144	139	135	128	130	131	129	130	133	132	129	130
20	1220946	64	61	63	59	60	53	95	91	93	96	92	90	93	88	89	139	135	116	119	117	117	115	112	114	113	116	120	125	127	125
21	1226095	104	102	100	99	97	96	96	97	99	99	100	101	101	101	102	152	153	172	142	144	139	141	126	128	125	117	125	120	134	135
22	880453	81	88	86	90	88	90	81	89	84	88	86	85	80	78	80	141	137	147	127	121	123	128	128	130	126	126	126	129	126	126
23	1250175	64	65	66	64	62	62	63	61	60	59	61	60	63	61	62	185	180	179	176	175	162	156	155	153	154	152	150	148	145	141
24	1159595	76	80	69	78	80	79	81	74	80	77	75	75	72	70	72	120	122	124	123	125	129	113	132	132	135	131	137	128	119	124
25	1263860	92	91	91	91	90	90	90	94	91	90	88	88	89	84	85	197	189	181	176	178	177	172	177	175	176	163	160	162	162	163
26	1279780	81	78	72	75	72	67	71	70	65	63	67	59	64	60	59	142	156	158	146	152	146	137	146	138	131	130	123	125	126	122
27	1278965	104	102	102	102	104	104	106	108	108	109	109	106	108	110	109	139	135	127	140	132	133	129	132	129	129	125	117	100	99	115
28	851329	91	92	91	89	89	85	89	87	84	84	82	82	80	81	80	130	128	127	134	137	133	128	131	126	126	124	118	114	109	115
29	1286866	93	91	90	92	88	86	89	86	84	85	83	82	80	81	81	113	113	119	122	119	117	109	110	104	108	113	106	110	107	105
30	1288163	67	65	66	64	63	61	64	62	63	61	60	62	63	59	62	166	169	155	142	141	131	125	119	122	124	121	125	126	120	123
31	1288805	75	76	74	74	73	69	67	74	72	70	68	69	64	65	67	154	133	143	139	136	140	146	137	135	142	142	138	140	133	132
32	465933	60	62	61	59	59	60	61	61	62	60	63	59	60	59	61	174	170	169	167	174	170	166	164	165	162	164	160	160	162	158
33	205995	97	98	95	93	96	94	91	89	90	87	85	85	86	83	82	174	171	168	169	153	155	147	155	163	146	145	141	135	127	131
34	1251105	87	88	88	90	87	84	82	81	77	81	68	67	74	72	64	136	130	132	123	128	129	123	120	120	123	119	126	120	110	129
35	172912	83	79	77	78	79	83	84	83	82	82	83	82	81	81	80	136	125	129	123	128	119	104	104	102	96	96	109	123	124	117
36	1294393	62	63	61	61	64	62	63	62	61	59	61	60	62	63	59	126	124	126	122	124	122	120	122	124	120	118	116	118	117	114
37	5465	80	77	76	77	74	75	75	74	75	71	72	75	72	70	67	109	117	109	116	107	112	119	110	113	109	113	109	113	115	111
38	1333223	66	70	69	68	62	61	66	65	64	62	65	62	64	63	62	155	150	157	152	157	146	142	148	147	140	144	140	148	152	150
39	1257225	67	66	67	67	65	67	65	64	66	63	66	67	64	65	64	187	191	176	148	136	134	113	111	108	107	118	126	124	122	119
40	1079975	66	67	70	69	71	66	60	67	66	65	62	61	63	60	62	127	148	141	142	137	131	124	134	126	128	134	136	130	128	126
41	1343374	59	59	62	59	60	60	63	61	60	59	61	59	60	61	62	109	110	116	110	104	102	100	100	102	100	102	104	100	102	98
42	1360206	80	81	83	82	80	79	79	81	80	78	78	78	77	75	76	152	154	148	149	151	148	150	146	149	147	145	141	143	138	142
43	1362436	75	75	74	74	72	73	74	71	70	69	67	70	67	68	67	120	121	119	118	120	117	118	116	117	115	115	114	112	110	109
44	1361325	84	82	85	81	82	81	79	80	78	76	78	77	75	73	74	144	142	140	138	141	140	137	136	137	135	133	135	134	131	130
45	1361991	64	61	63	60	62	59	61	64	63	60	62	62	60	63	61	115	112	114	111	109	110	108	105	101	96	93	115	114	112	114
46	1358680	68	66	69	65	63	64	60	62	62	61	64	62	60	63	61	130	131	128	127	129	126	127	124	126	125	121	119	119	116	118
47	1364713	82	84	80	78	77	79	76	75	75	77	73	75	76	74	73	134	132	133	130	131	128	130	129	132	126	124	125	125	123	121
48	1181081	85	87	84	86	85	81	79	78	80	77	76	73	75	74	74	148	145	147	143	140	142	144	141	138	136	139	135	132	133	130
49	1366346	96	95	93	94	91	93	93	90	88	89	86	85	89	86	87	140	141	138	136	139	137	137	134	135	132	133	131	134	132	129
50	1331830	69	66	67	65	66	64	64	66	62	65	63	60	61	59	60	130	132	128	130	126	129	128	128	124	121	125	123	121	120	118

Sr. No	MRD. No	SBP_18 Minute	SBP_20 Minute	SBP_22 Minute	SBP_24 Minute	SBP_26 Minute	SBP_28 Minute	SBP_30 Minute	DBP_Baseline	DBP_0 Minute	DBP_1 Minute	DBP_2 Minute	DBP_3 Minute	DBP_4 Minute	DBP_5 Minute	DBP_6 Minute	DBP_7 Minute	DBP_8 Minute	DBP_9 Minute	DBP_10 Minute	DBP_12 Minute	DBP_14 Minute	DBP_16 Minute	DBP_18 Minute	DBP_20 Minute	DBP_22 Minute	DBP_24 Minute	DBP_26 Minute	DBP_28 Minute	DBP_30 Minute
1	1131008	95	98	93	91	95	88	92	80	64	59	50	51	60	60	62	58	60	58	56	55	56	52	56	53	48	52	52	51	51
2	1133412	113	110	115	115	113	113	114	78	76	72	76	73	73	73	76	71	70	72	72	74	73	72	72	73	68	78	77	75	72
3	1148511	114	119	109	112	119	111	112	100	96	86	80	71	72	50	72	68	73	72	70	69	65	66	64	64	68	64	67	66	70
4	1157630	128	126	122	124	120	126	127	80	70	75	57	48	56	54	53	54	53	56	57	60	52	65	60	61	48	51	47	50	48
5	1163282	111	104	116	115	112	110	113	70	60	68	66	66	64	59	56	63	55	55	47	58	64	68	62	57	70	52	50	58	63
6	937953	90	84	84	92	100	90	86	82	86	78	56	70	66	60	58	60	61	64	57	56	52	60	56	51	50	57	64	60	55
7	1156161	102	100	108	106	101	103	106	84	55	60	56	58	58	43	47	46	63	72	70	68	66	70	64	69	68	66	72	67	65
8	1166498	112	112	114	108	108	114	111	56	60	63	66	66	65	59	59	56	55	56	53	59	59	58	56	57	51	60	58	55	58
9	1206053	134	134	139	131	127	134	139	88	79	80	79	73	78	83	80	76	75	80	75	72	77	76	78	77	77	76	79	78	82
10	80881	120	125	127	121	122	120	126	80	96	99	84	81	81	83	74	69	73	76	76	78	75	77	79	78	77	77	76	78	80
11	896483	112	95	125	105	121	120	118	89	77	73	74	73	75	74	72	72	71	63	66	70	68	73	72	65	90	66	76	76	78
12	126108	116	116	115	113	116	114	113	81	84	90	79	75	74	75	72	72	69	67	67	71	70	69	67	71	72	70	70	70	71
13	1186289	135	133	130	127	128	135	126	90	94	95	93	88	91	87	84	83	80	79	80	78	77	78	80	79	74	75	79	75	75
14	1216924	136	139	136	131	134	132	132	95	86	80	90	84	78	74	80	79	76	80	64	76	74	73	80	75	77	67	78	74	77
15	1203914	120	122	127	120	131	125	125	90	81	76	79	80	76	73	69	69	70	69	70	69	68	67	71	69	72	72	67	72	68
16	1213043	121	117	117	122	117	123	118	90	86	81	92	86	91	89	82	80	78	77	73	84	76	72	67	67	68	64	68	72	67
17	1217569	113	110	112	108	109	108	110	76	80	76	69	72	75	72	71	63	64	59	62	58	54	50	64	65	59	63	61	55	55
18	850548	128	133	131	132	128	128	130	86	92	82	78	58	63	63	62	63	67	66	67	68	63	77	69	85	82	87	82	84	82
19	145203	131	130	132	133	132	132	126	95	94	91	94	86	86	81	85	87	80	82	86	85	81	80	84	87	82	86	83	81	82
20	1220946	124	123	122	125	126	127	129	84	91	83	78	76	77	73	73	74	74	74	70	76	78	75	75	80	76	76	76	75	72
21	1226095	141	131	122	140	142	145	144	107	87	79	91	82	83	77	77	72	71	74	71	79	81	82	82	79	81	86	86	85	83
22	880453	130	123	130	128	130	134	130	87	81	79	73	69	56	66	59	53	66	63	65	70	62	56	65	66	68	69	70	60	68
23	1250175	143	143	140	141	139	150	143	88	92	92	81	87	80	76	75	72	74	74	70	73	71	70	69	73	71	68	73	72	71
24	1159595	132	128	130	121	122	118	126	70	81	93	83	90	88	81	83	86	80	82	57	77	76	86	79	79	79	83	78	83	82
25	1263860	172	176	161	164	169	161	159	93	83	82	78	89	79	88	82	82	74	75	74	76	72	75	76	80	70	72	79	74	71
26	1279780	115	118	120	117	115	114	112	82	88	87	77	80	78	81	83	80	79	73	72	71	72	67	65	68	67	66	66	59	61
27	1278965	122	108	99	108	90	107	94	80	77	75	82	74	74	73	69	68	70	68	74	60	57	67	68	63	54	62	60	62	57
28	851329	114	119	116	115	119	118	113	75	76	70	75	74	76	74	72	74	70	68	69	68	69	68	67	68	67	66	71	66	68
29	1286866	108	106	104	106	109	103	100	58	65	66	58	57	56	62	60	58	56	56	54	54	50	52	48	48	54	52	48	50	52
30	1288163	121	124	122	128	123	125	125	80	90	88	82	75	70	71	69	68	66	65	64	65	66	66	66	66	67	69	69	71	70
31	1288805	135	136	141	137	129	134	136	80	86	80	87	84	84	83	81	80	82	79	78	74	76	79	84	85	83	73	82	76	74
32	465933	156	158	160	156	157	156	154	100	102	98	96	92	92	92	89	90	88	85	86	86	84	84	82	80	80	79	80	82	78
33	205995	142	123	142	124	129	141	145	77	90	77	78	77	72	67	78	75	71	72	72	72	67	77	71	66	71	69	67	73	72
34	1251105	120	119	124	120	120	123	120	82	84	86	87	85	83	82	77	76	83	80	84	74	77	71	75	75	76	75	74	72	70
35	172912	116	109	104	102	106	102	99	86	84	84	87	78	74	70	66	65	61	62	78	76	75	70	69	70	64	64	66	64	65
36	1294393	112	115	110	112	114	114	110	75	74	72	74	72	76	76	70	71	68	70	66	68	70	68	71	69	67	69	66	65	64
37	5465	110	110	107	106	105	110	104	79	81	75	67	75	72	73	68	70	70	70	68	68	64	72	71	71	70	68	72	71	68
38	1333223	148	152	147	148	146	147	144	98	93	102	91	97	83	88	89	86	85	87	86	97	90	88	86	85	86	84	83	84	82
39	1257225	116	110	128	130	125	126	124	97	92	80	75	71	68	56	58	61	60	64	70	68	60	62	56	60	68	62	59	64	65
40	1079975	128	126	124	124	127	125	122	78	94	91	78	77	76	74	71	72	73	73	76	74	70	65	74	72	64	62	60	63	66
41	1343374	94	90	112	110	108	114	112	64	57	65	59	60	55	56	57	58	58	55	58	62	56	60	58	54	63	65	58	56	60
42	1360206	138	139	136	137	140	136	135	86	85	84	80	82	83	81	80	80	79	81	78	76	77	77	74	76	75	72	70	73	70
43	1362436	110	107	108	111	107	106	106	64	65	64	64	62	63	61	60	60	62	60	59	57	59	58	56	58	56	54	55	53	52
44	1361325	132	128	129	127	124	125	122	70	71	68	67	65	65	63	61	62	63	60	61	59	57	59	58	56	54	56	55	51	53
45	1361991	110	108	111	107	106	107	104	61	60	58	60	59	56	58	57	55	52	49	57	58	58	59	56	55	53	55	56	54	54
46	1358680	115	117	114	112	114	111	110	75	76	73	71	70	72	71	68	70	69	66	65	63	62	62	63	61	59	60	62	59	58
47	1364713	123	122	120	121	118	119	117	71	72	70	69	71	73	68	70	67	68	67	65	64	66	63	60	62	60	61	61	63	60
48	1181081	129	125	121	123	122	120	121	83	81	80	83	80	79	75	78	76	77	73	74	72	69	71	70	68	70	69	67	66	65
49	1366346	130	130	128	131	127	129	128	75	74	71	72	68	70	69	65	65	66	64	67	64	61	62	63	59	60	57	59	58	60
50	1331830	120	117	119	116	114	112	110	68	66	62	64	61	60	58	56	60	59	56	57	53	54	52	54	55	52	53	52	52	50

Sr. No	MRD. No	MAP_Baseline	MAP_0 Minute	MAP_1 Minute	MAP_2 Minute	MAP_3 Minute	MAP_4 Minute	MAP_5 Minute	MAP_6 Minute	MAP_7 Minute	MAP_8 Minute	MAP_9 Minute	MAP_10 Minute	MAP_12 Minute	MAP_14 Minute	MAP_16 Minute	MAP_18 Minute	MAP_20 Minute	MAP_22 Minute	MAP_24 Minute	MAP_26 Minute	MAP_28 Minute	MAP_30 Minute	Hypotension	Times Hypotension	Bradycardia	COMPLICATION_ Baseline
1	1131008	92	80	75	68	66	75	76	76	73	73	71	71	69	70	67	69	68	63	65	66	63	64	-	-	-	-
2	1133412	99	90	88	90	93	87	88	92	88	85	88	89	89	89	89	89	87	85	93	91	93	89	-	-	-	-
3	1148511	123	118	108	102	103	104	103	99	97	100	91	91	89	85	84	83	87	89	91	91	88	90	-	-	-	-
4	1157630	99	97	95	93	79	84	76	81	85	84	81	87	81	82	94	90	88	83	87	81	87	87	-	-	-	-
5	1163282	83	73	90	81	89	82	84	85	86	87	83	80	79	84	90	82	75	94	78	70	75	79	-	-	-	-
6	937953	99	100	-	65	84	79	72	70	71	79	76	71	67	64	73	69	65	61	69	78	74	64	y	3	-	-
7	1156161	95	90	85	86	81	81	60	108	58	80	87	82	80	79	81	77	79	81	79	81	79	78	-	-	-	-
8	1166498	72	82	89	85	84	84	81	78	77	76	76	79	81	80	80	80	81	85	82	80	78	80	-	-	-	-
9	1206053	102	109	102	101	97	96	102	108	103	101	102	98	102	100	98	103	107	103	102	98	100	106	-	-	-	-
10	80881	96	110	112	109	98	98	105	94	91	88	88	94	94	95	95	93	96	94	91	96	93	93	-	-	-	-
11	896483	111	93	88	88	88	88	90	88	95	87	85	85	83	82	90	87	76	105	84	94	89	95	y	1	-	-
12	126108	98	98	104	97	89	92	90	87	84	87	85	84	85	87	90	88	91	88	85	86	88	88	-	-	-	-
13	1186289	119	130	126	126	117	116	117	112	109	107	104	102	99	98	95	103	102	96	97	98	100	96	-	-	-	-
14	1216924	118	104	110	109	107	95	95	110	105	99	99	103	104	104	93	105	104	98	90	98	98	96	-	-	-	-
15	1203914	113	106	104	105	107	102	101	95	94	95	96	94	94	92	93	92	94	94	92	92	92	92	-	-	y	-
16	1213043	123	117	116	130	107	110	109	102	100	97	96	92	98	91	91	88	88	84	83	84	89	84	-	-	-	-
17	1217569	96	96	90	89	88	88	89	88	84	85	80	80	82	91	82	88	86	83	82	83	86	83	-	-	-	-
18	850548	102	108	101	100	71	78	78	77	77	82	81	82	82	97	101	86	103	104	106	101	100	98	-	-	-	-
19	145203	109	115	118	116	111	107	101	104	101	96	98	102	109	104	100	106	105	107	109	104	100	101	-	-	-	-
20	1220946	107	109	101	93	93	96	92	86	93	89	93	93	97	99	97	95	98	96	96	96	99	97	-	-	y	-
21	1226095	121	115	116	104	109	106	99	94	92	90	93	92	97	103	107	107	104	95	109	110	111	109	-	-	-	-
22	880453	116	100	109	94	88	81	91	89	94	89	91	88	88	88	87	90	88	92	93	97	94	98	-	-	-	-
23	1250175	136	129	129	128	121	123	113	111	108	115	109	105	111	106	104	102	104	105	105	105	107	107	-	-	-	-
24	1159595	94	98	103	100	101	100	95	101	104	99	100	100	98	94	99	94	98	99	95	92	95	100	-	-	-	-
25	1263860	140	125	130	123	126	122	124	123	122	117	118	112	109	102	113	102	123	111	115	115	118	108	-	-	-	-
26	1279780	109	120	120	113	109	101	102	107	102	97	94	92	89	90	84	84	84	84	82	83	81	78	-	-	-	-
27	1278965	101	96	93	101	97	96	95	92	90	89	89	83	74	72	82	85	76	68	77	70	75	72	y	2	-	-
28	851329	101	100	93	100	100	95	96	96	96	91	89	87	85	83	87	88	89	89	86	92	89	87	-	-	-	-
29	1286866	79	89	86	83	87	82	82	81	80	76	82	79	72	69	69	68	67	70	70	68	67	68	-	-	y	-
30	1288163	122	130	126	115	106	99	94	93	89	91	90	90	91	89	90	93	93	92	94	93	97	99	-	-	-	-
31	1288805	115	103	110	108	104	108	111	103	103	107	105	104	103	106	101	105	106	110	102	104	104	99	-	-	-	-
32	465933	150	150	146	136	134	127	127	121	115	112	111	110	110	110	108	106	106	107	105	105	106	103	-	-	-	-
33	205995	113	143	114	112	108	105	108	109	111	104	102	107	121	96	100	101	95	105	93	95	99	103	-	-	y	-
34	1251105	100	99	101	108	106	104	100	98	98	102	97	102	98	92	93	96	98	99	97	92	96	94	-	-	-	-
35	172912	106	103	104	107	99	91	84	84	81	75	73	92	99	96	91	89	88	81	77	81	81	80	y	1	-	-
36	1294393	92	90	90	90	89	91	90	87	88	85	86	83	84	85	83	84	84	81	83	82	81	79	-	-	-	-
37	5465	93	91	86	87	88	89	90	84	88	85	88	85	85	81	88	87	86	83	84	87	86	83	-	-	-	-
38	1333223	125	118	125	120	129	119	116	118	116	115	119	111	116	110	108	106	107	106	105	104	105	102	-	-	-	-
39	1257225	144	134	126	108	101	97	85	76	82	82	84	91	87	80	81	76	76	88	84	81	84	84	y	3	-	-
40	1079975	99	119	117	105	106	104	93	99	93	95	94	95	95	90	94	99	92	84	82	82	83	84	-	-	-	-
41	1343374	84	83	84	82	78	74	72	75	73	74	72	73	75	71	73	70	66	79	80	74	75	77	y	1	-	-
42	1360206	108	108	105	103	105	104	104	102	103	102	102	99	98	97	98	95	97	95	94	93	94	92	-	-	-	-
43	1362436	83	84	82	82	81	81	80	79	79	80	78	77	75	76	75	74	74	73	73	72	70	70	-	-	-	-
44	1361325	95	95	92	91	90	90	88	86	87	87	84	86	84	82	82	82	80	79	79	78	76	76	-	-	-	-
45	1361991	79	77	77	77	76	74	75	73	70	67	63	76	77	76	77	74	73	72	72	73	72	71	y	1	-	-
46	1358680	93	94	91	90	90	90	89	87	88	88	84	83	82	80	80	80	79	77	77	80	76	75	-	-	-	-
47	1364713	92	92	91	89	91	91	89	89	89	87	86	85	84	85	82	81	82	80	81	80	82	79	-	-	-	-
48	1181081	105	102	102	103	100	100	98	99	97	97	95	94	92	90	91	89	87	87	87	85	84	83	-	-	-	-
49	1366346	97	96	93	93	92	92	92	88	88	88	87	88	87	84	84	85	82	83	81	82	82	83	-	-	-	-
50	1331830	89	88	84	86	83	83	81	80	81	79	79	79	76	76	74	76	75	74	74	73	72	70	-	-	-	-

Sr. No	MRD. No	COMPLICATION_ 0 Minute	COMPLICATION_ 1 Minute	COMPLICATION_ 2 Minute	COMPLICATION_ 3 Minute	COMPLICATION_ 4 Minute	COMPLICATION_ 5 Minute	COMPLICATION_ 6 Minute	COMPLICATION_ 7 Minute	COMPLICATION_ 8 Minute	COMPLICATION_ 9 Minute	COMPLICATION_ 10 Minute	COMPLICATION_ 12 Minute	COMPLICATION_ 14 Minute	COMPLICATION_ 16 Minute	COMPLICATION_ 18 Minute
1	1131008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1133412	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1148511	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1157630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1163282	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	937953	-	-	Hypotension	-	-	-	Hypotension	-	-	-	-	Hypotension	-	-	-
7	1156161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	1166498	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	1206053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	80881	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	896483	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	126108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1186289	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	1216924	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	1203914	-	-	-	-	-	-	-	Bradycardia	-	-	-	-	-	-	-
16	1213043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	1217569	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	850548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	145203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1220946	-	-	-	-	-	-	-	-	-	-	-	Bradycardia	-	-	-
21	1226095	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	880453	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	1250175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	1159595	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	1263860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	1279780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	1278965	-	-	-	-	-	-	-	-	-	-	-	-	-	Hypotension	-
28	851329	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	1286866	-	-	-	-	-	Bradycardia	-	-	-	-	-	-	-	-	-
30	1288163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	1288805	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	465933	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	205995	-	-	-	Bradycardia	-	-	-	-	-	-	-	-	-	-	-
34	1251105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	172912	-	-	-	-	-	-	-	-	Hypotension	-	-	-	-	-	-
36	1294393	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	5465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	1333223	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	1257225	-	-	-	-	-	Hypotension	-	Hypotension	-	-	-	-	-	-	-
40	1079975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	1343374	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	1360206	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	1362436	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	1361325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	1361991	-	-	-	-	-	-	-	-	-	Hypotension	-	-	-	-	-
46	1358680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	1364713	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	1181081	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	1366346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	1331830	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sr. No	MRD. No	COMPLICATION_ 20 Minute	COMPLICATION_ 22 Minute	COMPLICATION_ 24 Minute	COMPLICATION_ 26 Minute	COMPLICATION_ 28 Minute	COMPLICATION_ 30 Minute	INTERVENTION_ Baseline	INTERVENTION_ 0 Minute	INTERVENTION_ 1 Minute	INTERVENTION_ 2 Minute	INTERVENTION_ 3 Minute	INTERVENTION_ 4 Minute	INTERVENTION_ 5 Minute	INTERVENTION_ 6 Minute	INTERVENTION_7 Minute	INTERVENTION_ 8 Minute
1	1131008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1133412	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1148511	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1157630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1163282	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	937953	-	-	-	-	-	-	-	-	-	6mg Ephedrine	-	-	-	6mg Ephedrine	-	-
7	1156161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	1166498	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	1206053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	80881	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	896483	Hypotension	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	126108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1186289	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	1216924	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	1203914	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.36mg Atropine	-
16	1213043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	1217569	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	850548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	145203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1220946	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	1226095	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	880453	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	1250175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	1159595	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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26	1279780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	1278965	-	-	-	Hypotension	-	-	-	-	-	-	-	-	-	-	-	-
28	851329	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	1286866	-	-	-	-	-	-	-	-	-	-	-	-	0.6mg Atropine	-	-	-
30	1288163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	1288805	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	465933	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	205995	-	-	-	-	-	-	-	-	-	-	0.6mg Atropine	-	-	-	-	-
34	1251105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	172912	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6 mg Ephedrine
36	1294393	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	5465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	1333223	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	1257225	Hypotension	-	-	-	-	-	-	-	-	-	-	-	6mg Ephedrine	-	6mg Ephedrine	-
40	1079975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	1343374	Hypotension	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	1360206	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	1362436	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	1361325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	1361991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	1358680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	1364713	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	1181081	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	1366346	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	1331830	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sr. No	MRD. No	INTERVENTION_ 9 Minute	INTERVENTION_ 10 Minute	INTERVENTION_ 12 Minute	INTERVENTION_ 14 Minute	INTERVENTION_ 16 Minute	INTERVENTION_ 18 Minute	INTERVENTION_ 20 Minute	INTERVENTION_ 22 Minute	INTERVENTION_ 24 Minute	INTERVENTION_ 26 Minute	INTERVENTION_ 28 Minute	INTERVENTION_ 30 Minute
1	1131008	-	-	-	-	-	-	-	-	-	-	-	-
2	1133412	-	-	-	-	-	-	-	-	-	-	-	-
3	1148511	-	-	-	-	-	-	-	-	-	-	-	-
4	1157630	-	-	-	-	-	-	-	-	-	-	-	-
5	1163282	-	-	-	-	-	-	-	-	-	-	-	-
6	937953	-	-	-	-	-	-	-	-	-	-	-	-
7	1156161	-	-	-	-	-	-	-	-	-	-	-	-
8	1166498	-	-	-	-	-	-	-	-	-	-	-	-
9	1206053	-	-	-	-	-	-	-	-	-	-	-	-
10	80881	-	-	-	-	-	-	-	-	-	-	-	-
11	896483	-	-	-	-	-	-	6mg Ephedrine	-	-	-	-	-
12	126108	-	-	-	-	-	-	-	-	-	-	-	-
13	1186289	-	-	-	-	-	-	-	-	-	-	-	-
14	1216924	-	-	-	-	-	-	-	-	-	-	-	-
15	1203914	-	-	-	-	-	-	-	-	-	-	-	-
16	1213043	-	-	-	-	-	-	-	-	-	-	-	-
17	1217569	-	-	-	-	-	-	-	-	-	-	-	-
18	850548	-	-	-	-	-	-	-	-	-	-	-	-
19	145203	-	-	-	-	-	-	-	-	-	-	-	-
20	1220946	-	-	0.6mg Atropine	-	-	-	-	-	-	-	-	-
21	1226095	-	-	-	-	-	-	-	-	-	-	-	-
22	880453	-	-	-	-	-	-	-	-	-	-	-	-
23	1250175	-	-	-	-	-	-	-	-	-	-	-	-
24	1159595	-	-	-	-	-	-	-	-	-	-	-	-
25	1263860	-	-	-	-	-	-	-	-	-	-	-	-
26	1279780	-	-	-	-	-	-	-	-	-	-	-	-
27	1278965	-	-	-	-	6 mg Ephedrine	-	-	-	-	pinephrine @ 3ml	-	-
28	851329	-	-	-	-	-	-	-	-	-	-	-	-
29	1286866	-	-	-	-	-	-	-	-	-	-	-	-
30	1288163	-	-	-	-	-	-	-	-	-	-	-	-
31	1288805	-	-	-	-	-	-	-	-	-	-	-	-
32	465933	-	-	-	-	-	-	-	-	-	-	-	-
33	205995	-	-	-	-	-	-	-	-	-	-	-	-
34	1251105	-	-	-	-	-	-	-	-	-	-	-	-
35	172912	-	-	-	-	-	-	-	-	-	-	-	-
36	1294393	-	-	-	-	-	-	-	-	-	-	-	-
37	5465	-	-	-	-	-	-	-	-	-	-	-	-
38	1333223	-	-	-	-	-	-	-	-	-	-	-	-
39	1257225	-	-	-	-	-	-	6mg Ephedrine	-	-	-	-	-
40	1079975	-	-	-	-	-	-	-	-	-	-	-	-
41	1343374	-	-	-	-	-	-	6mg Ephedrine	-	-	-	-	-
42	1360206	-	-	-	-	-	-	-	-	-	-	-	-
43	1362436	-	-	-	-	-	-	-	-	-	-	-	-
44	1361325	-	-	-	-	-	-	-	-	-	-	-	-
45	1361991	6mg Ephedrine	-	-	-	-	-	-	-	-	-	-	-
46	1358680	-	-	-	-	-	-	-	-	-	-	-	-
47	1364713	-	-	-	-	-	-	-	-	-	-	-	-
48	1181081	-	-	-	-	-	-	-	-	-	-	-	-
49	1366346	-	-	-	-	-	-	-	-	-	-	-	-
50	1331830	-	-	-	-	-	-	-	-	-	-	-	-

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Date 04/11/21

The Principal,
DMC, Ludhiana.

Subject: Approval of Plan of Thesis.

This is to inform you that the Faculty of Medical Sciences in its meeting held on 29.10.2021 has approved the plan of thesis of **Sukhkamal Singh**, a student of your college for **MD Anaesthesiology** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Inferior vena cava collapsibility index vs internal jugular vein collapsibility index for prediction of post spinal hypotension.

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The student has to submit the four copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

27. *If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.*
28. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF MEDICINE

In

ANAESTHESIOLOGY

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

MARCH 2021

Dr SUKHKAMAL SINGH

DEPARTMENT OF ANAESTHESIOLOGY
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ABSTRACT OF PLAN OF THESIS

Title	INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION
For the degree of	M.D. Anaesthesia
Name of the candidate	Dr. Sukhkamal Singh
Supervisor	Dr. Suneet Kant Kathuria, Professor, Department of Anaesthesia, DMCH, Ludhiana
Co-supervisor	Dr. Udeyana Singh, Associate Professor, Department of Anaesthesia, DMCH, Ludhiana
Institution	Dayanand Medical College and Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: Inferior vena cava and internal jugular vein collapsibility index are being increasingly used as noninvasive tools to predict hypovolemia in emergency and critical care settings. Hypotension is a common intra operative complication after giving spinal anaesthesia, as a result of sympathetic blockade. Successful prediction of post spinal hypotension can help in adoption of appropriate preventive and treatment measures to minimise perioperative morbidity.

Aim of the Study: Comparison of inferior vena cava and internal jugular vein collapsibility index for prediction of post spinal hypotension.

Materials and methods: A prospective observational study will be conducted on 50 adult patients of ASA I, II and III scheduled to undergo elective surgery under spinal anaesthesia. The inferior vena cava collapsibility index and internal jugular vein collapsibility index will be assessed as a tool for prediction of post spinal hypotension. After giving spinal anaesthesia using a standard protocol, monitoring of heart rate, systolic, diastolic and mean blood pressure will be done upto 30 minutes to compare incidence and severity of hypotension.

Clinical significance: Successful prediction of hypotension after spinal anaesthesia may help in risk prognostication and reduction of perioperative morbidity.

Keywords: inferior vena cava, internal jugular vein, collapsibility index, spinal anaesthesia, hypotension.

(Signature)	(Signature)	(Signature)	(Signature)
Candidate	Co-supervisor	Supervisor	Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION"** exist in the Department of Anaesthesiology at Dayanand Medical College and Hospital, Ludhiana and will be provided to the candidate. We will see that the data being included in the thesis are genuine and is collected by the candidate himself under our supervision and guidance.

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Place: Ludhiana

Date: 15/4/21

APPROVAL PROFORMA
BY
RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

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Department	Anaesthesia
Topic of Thesis	INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION
Likely date of appearing in PG examination	MAY-JUNE 2023
Date of enrollment	26th July 2020
Name of Head of Department	Dr. Dinesh Sood
1) Supervisor **2) Co-Supervisor**	Dr. Suneet Kant Kathuria Dr. Udeyana Singh
Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
Dr. Harpreet Kaur (Professor & Head, Pathology)	Mr. R K Sharma (Legal Expert)
Dr. Jaspal Singh (Professor & Head, Surgery)	Dr. Ramit Mahajan (Associate Professor, Gastroenterology)
Dr. Dinesh Gupta (Professor & Head, Medicine)	Dr. Anu Sharma (Professor, Anatomy)
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Dr. Sandeep Puri
Chairperson
Research Committee

Approved: Yes / ~~No~~

Prof. Arvind Malhotra
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Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	DR SUKHKAMAL SINGH VPO BHUNGARNI, TEH AND DISTT HOSHIARPUR
2	NAME OF THE INSTITUTE	DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA
3	COURSE OF STUDY AND SUBJECT	BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT
4	DATE OF ADMISSION OF COURSE	26TH,JULY,2020
5	TITLE OF THE TOPIC	INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

Spinal anaesthesia is frequently used in anaesthesia practice. The common side effects of sub arachnoid block are bradycardia and hypotension. Incidence of post spinal hypotension is about 15-33 % which, if severe and untreated can result in organ hypo perfusion and ischaemic events. Main reasons for decrease in systolic blood pressure are decrease in systemic vascular resistance and cardiac output [1].Patients' susceptibility to intraoperative hypotension can be influenced by the preoperative volume status, associatedcomorbidities, physical status, pre-operative medications andfasting duration[2, 3].

Prediction of hypotension and adoption of appropriate preventive measures like optimization of fluid status and early institution of appropriate treatmenthelps to reduce morbidity and risk of serious complicationslike stroke, heart and kidney failure, prolonged hospitalisation and postoperative mortality[4]. Many techniques have been tried to prevent post spinal hypotension, such as intravenous volume preload, co-load or use of prophylactic vasopressors. However, empirical volume loading carries the potential of volume overload, particularly in patients with cardiac disease. The successful prediction ofhypotension is necessary to guide appropriate volume loading to prevent post spinal hypotension[5].

Various invasive and non-invasive methods have beenemployed to estimatethe volumestatus and hypotension vulnerability in critically ill patients like:

- Baseline heart rate of the patient (HR)
- Jugular venous pressure measurement (JVP)
- Central venous pressure monitoring (CVP)
- Passive leg raise (PLR) test
- Perfusion index (PI)
- Inferior vena cava collapsibility index(IVC-CI)
- Internal jugular veincollapsibility index (IJV-CI)

The role of clinical examination in assessing the intravascular volume status has been found to be unreliable,as itlacks accuracy

&precision[6].Studies have been done on baseline heart rate as a predictive parameter of hypotension. As the higher heart rate reflects higher sympathetic activity and thus, will result in more hypotension after spinal sympathetic blockade[7]. Measuring central venous pressure (CVP) by inserting a central venous catheter is though a gold standard technique, but it is invasive, time-consuming and associated with complications [6].Height of external jugular venous pulsation when used as indirect measure of CVP has a poor sensitivity[6].

The non-invasive methods like perfusion index using Masimo pulse oximeter,inferior vena cava (IVC) diameter, collapsibility or caval index, IJV diameter, IJV collapsibility index using ultrasonography etc. have been used as alternate approach to invasive CVP measurement, but with varying results.

Perfusion index [PI] is a relatively a newer, simple and cost effective method of assessing peripheral perfusion[8]. It is calculated as the ratio between the amplitude of the pulsatile component (arterial compartment) to non-pulsatile component (venous and capillary blood, and other tissues) of the light reaching the detector of the pulse-oximeter. But, PI is totally oximeter based parameter and value of perfusion index can be variable due to incorrect sensor placement and motion artifacts[9].PI is alsoaffected by factors such as body temperature, psychological stress and anxiety, which can induce sympathetic activation. It is difficult to control these factors in awake patients[10].

The inferior vena cava (IVC) is a compliant vessel whose size and shape vary with changes in CVP and intravascular volume[11]. Therefore, sonographic measurement of variation in IVC diameter with respiration and IVC collapsibility index represent an effective and non-invasive method of estimating fluid status.

IVC Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

Zhang found the cut off value of IVC collapsibility index to be 43% while predicting hypotension in general anaesthesia[2].In 10%–15% of patients,

IVC measurement is difficult /not possible due to obesity, surgical dressings and drains, excessive intra-abdominal gas, extrinsic structures compressing IVC, increased intra-abdominal pressure, increased pulmonary artery pressure, tricuspid, or pulmonary valvular disease etc.Furthermore,it is important to note that changes in the intra-thoracic pressure and breathing pattern significantly affect the IVC diameter in a spontaneously breathing patient[12,13].

Many parameters of the internal jugular vein(IJV) are being increasingly used as an alternative to IVC measurements, to indirectly measure the fluid status.Few studies are available on the IJV diameter, cross-sectional area, and collapsibility index (CI) by ultrasonography as a measure of fluid status of critically ill patients[14,15].Anterior-posterior [AP] diameter of internal jugular vein between 5.7-8.3 mm, roughly corresponds to CVP of < 10 cm of H_2O and its values between 11.2 - 13.8 mm, correspond to CVP > 10 cm of H_2O[13]. Collapsibility index [CI] of internal jugular vein can be derived from AP diameter and is defined as under**:**

IJV Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter-Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

In intensive care unit, Kilu et al found that patients withIJV diameter collapsibility index> 39% are considered to be more prone to hypotension [14]. So, ultrasound guided IJV collapsibility index can provide an extra edge in clinical scenarios where IVC is difficult to visualise.

Most of thestudies on prediction of hypotension have been done in critically ill ICU patients usingIVC collapsibility measurements,but only a limited number of studies are available for prediction of hypotension in spinal anaesthesia.We hypothesiseto comparethe ability of inferior vena cava collapsibility index and internal jugular vein collapsibility index ineffectively predicting hypotension after spinal anaesthesia.

6.2REVIEW OF LITERATURE

Spinal sympathectomy is the root cause of hypotension after spinal anaesthesia. Due to pooling of blood in lower extremities of the body, the preload decreases further, thereby compromising the blood perfusion of vital organs. Both baseline volume status and baseline vascular tone have influence over the degree of hypotension after spinal anaesthesia. The attenuation of compensatory sympathetic vasoconstriction in a hypovolemic patient further adds to patients' vulnerability to hypotension. Efforts have been made in the previous years to reduce such clinical scenarios and prevent the patient from detrimental effects of hypotension. Michael A Frolich and Donald Caton implicated the role of baseline heart rate in estimating post spinal hypotension in obstetrical patients. Keeping a cut off value of 90 beats per minute, they allocated two groups of patients having heart rate < 90 and > 90 beats. It was found that higher baseline heart rate reflects a higher sympathetic tone in a person. Individuals with higher sympathetic activity are more prone to develop hypotension as a result of spinal sympathetic blockade [7].

Ajeet G et al, performed a prospective blinded study to determine the usefulness of external jugular vein [EJV] in detecting abnormal CVP valuesby comparing it with CVP measured by a central venous catheter in the ICU setting. They confirmed that the EJV is easier to visualise and depicts abnormally low and high CVP with remarkable precision. The cut off points for low and high CVP were taken as 5cm and 10cm of H_2O respectively.Taking CVP measurement by central venous catheter as a gold standard, they concluded that EJV examination is a reliable parameter of detecting low and high CVP levels but it had a few limitations. The values get variable by length of neck and any anatomical abnormalities in the patient. Moreover, EJV is difficult to visualise in obese patients and cannot detect very high CVP values. Observer's bias is another significant limitation for EJV examination[16].

Ginosar .Y. Weiniger et al hypothesised that pulse oximeter perfusion index[PI] provides an earlier indication of sympathectomy following epidural anaesthesia than skin temperature and arterial pressure. A total of 40 patients received lumbar epidural catheters and PI in the toe, mean arterial pressure, and toe temperature were assessed at baseline

5,10,15,20 minutes following epidural anaesthesia. Clinically sympathectomy was defined as 100% increase in perfusion index, 15% decrease in mean arterial pressure, 1° increase in toe temperature. They concluded that perfusion index was an earlier and sensitive indicator of sympathectomy[17].

S. Toyama, M. Kakumoto determined that higher baseline perfusion index reflected lower peripheral vascular tone and hence fall in systolic blood pressure was much more significant in parturients with high baseline perfusion index. A baseline perfusion index cut off point of 3.5 was used to identify patients at risk of hypotension[1].Duggappa et al also confirmed this finding in patients undergoing LSCS [18].

M. Yokose found that it is difficult to determine baseline perfusion index [PI] because the PI fluctuates every few seconds, and it may affect the interpretation of the result. PI is commonly affected by factors such as movement, temperature, psychological stress and anxiety, which can induce sympathetic activation. It is difficult to control these factors in all awake patients. Further examination is necessary to elucidate whether the PI is a truly reliable index[10].

Cavallaro et al conducted a study to find the ability of passive leg raising-induced changes in cardiac output (PLR-cCO) and in arterial pulse pressure (PLR-cPP) to predict fluid responsiveness. They concluded that passive leg raising-induced changes in cardiac output can reliably predict fluid responsiveness and has a significantly higher predictive value than PLR-cPP[19].

Zhang and Critchley suggested that pre-operative ultrasonographic measurement of IVCCI had a good predictive value for hypotension after induction of general anaesthesia, with a sensitivity of 78.6% and a specificity of 91.7% at a cut-off value of 43% [2].

Multivariate logistic regression analysis was performed by Salama and Elkashlan to detect the most important predictors of post spinal hypotension and it was found that caval aorta index was the most significant predictor of it. ROC curve analysis showed that caval aorta index had a sensitivity of 96%, a specificity of 88%, and an accuracy of 95% to predict post spinal hypotension at a cut-off point less than 1.2.

Whereas, IVC collapsibility index had a sensitivity of 84%, a specificity of 77% and an accuracy of 84% at a cut-off point more than 44.7% [5].

Kilic et al focused on the determination of IJV sonographic examination in prediction of post spinal hypotension. Compared to IVC imaging, sonographic evaluation of IJV was easier and time-saving. Additionally, it was found that IVC imaging cannot be possible in a group of patients, due to abdominal gas shadow and obesity. Moreover, anesthesiologists are more familiar to IJV anatomy as they frequently perform ultrasound-guided central IJV catheterization in their routine practice [4].

Killu and team analysed that IJV diameter collapsibility index of > 39% can be associated with hypovolemia. According to statistical analysis, the area under the curve for their study was equivalent to area under the curve using central venous pressure for hypovolemia [14].

Aleksandr Urakov et al aimed at establishing the values of internal jugular vein anterior-posterior [AP] and medial-lateral sizes in patients with hypovolemia. In their study on 25 adult Intensive care unit patients, they found that anterior-posterior vein diameter in patients with hypovolemia was significantly less than medial-lateral vein diameter during inhalation as well as exhalation. The value of AP diameter < 7 mm was recorded in 20 out of 25 patients whereas contrary to that only 6 patients had medial lateral diameter < 7 mm. So change in AP diameter was found to be a better predictor in determining hypovolemia [20].

Haitham Md Jassim et al enrolled 70 ICU patients in comparing the bedside ultrasound estimation of IJV collapsibility index with IVC collapsibility index and invasively monitored central venous pressure [CVP]. They calculated the IJV cross sectional area [CSA] collapsibility index at 0^0 and 30^0 head elevation position. The most suitable cut off value determined for IJV cross sectional CI at 0^0 was > 14.1 with sensitivity and specificity ranging between 73-82% in predicting CVP <10. A cut off value >19 was found to be an optimum for IJV cross sectional CI at 30^0 with similar sensitivity and specificity [6].

In another study Avcil et al formulated that the diameter of IJV correlated moderately with CVP, whereas IVC diameter and its collapsibility index

correlated poorly with CVP. They concluded that IVC index has better diagnostic performance for estimating higher CVP, whereas IJV cross sectional area, maximum diameter and IVC maximum diameter showed greater sensitivity & negative predicitive value for estimating low CVP[21].

So all the above studies provide us a good reference as anon-invasive parameter of depicting hypovolemia and low CVPin critically ill patients. To prevent post spinal hypo-perfusion, these parameters can provide us an extra edge over invasive methods for early prediction and timely management of post spinal hypotension. Therefore, we have planned to compare IVC and IJV diameter collapsibility index for prediction of post spinal hypotension.

6.3 AIMS AND OBJECTIVES OF THE STUDY

- To compare efficacy of Inferior vena cava collapsibility index and internal jugular vein collapsibility index in prediction of hypotension after spinal anaesthesia.

SECONDARY AIM:

- To compare IJV collapsibility index at $0^0$and 30^0 head elevated position in prediction of post spinal hypotension.

7. MATERIALS AND METHODS

7.1 SOURCE OF DATA

This prospective, observational study will be conducted in Department of Anaesthesiology, Dayanand Medical College & Hospital, Ludhiana after approval by Institutional Ethics Committee on a total of 50 adult patients undergoing spinal anaesthesia. A written informed consent will be obtained from all patients.

7.2 METHOD OF COLLECTION OF DATA

Inclusion Criteria

- Patients > 18 years of age.
- Patients undergoing spinal anaesthesia for an elective surgery.
- ASA I, II, III patients.

Exclusion Criterion

- Consent refusal by the patient for study
- Infection at the site of spinal injection
- Patients with severe hypovolemia or haemorrhagic shock
- Pre-existing severe neurological, cardiac, renal or liver disease
- Thrombocytopenia and Coagulopathies
- Patient currently taking anti-coagulant/anti-platelet therapy
- Spine injury

PRE ANAESTHETIC CHECKUP

A complete pre anaesthetic check-up will be done which will include detailed history including allergy to any drug, pre-existing co-morbidities and medication history, general, physical and systemic examination and relevant laboratory investigations as per institutional protocol. The demographic details including age, sex, height, weight and BMI etc. will be recorded. Patient will be explained about the study protocol and a written informed consent will be obtained.

ANAESTHESIA TECHNIQUE:

After shifting the patient into operating room, the patient will be positioned supine on operating table. Standard monitoring with electrocardiography, automated non invasive blood pressure measurement and pulse oximetry will be initiated. IV access will be established using an 18G cannula.

Baseline values of HR, SpO_2, systolic, diastolicand mean blood pressure will be recorded.

A curvilinear USG probe of 1-5 MHz will be used for IVC imaging.The transducer will be placed in the subxiphoid region in a longitudinal position and measurements will be made just distal to the IVC-hepatic vein junction, approximately 3 to 4 cm distal to the right atrium. The IVC will be identified by Doppler waveform, compressibility and phasic collapse with respiration. The maximum (IVCD) and minimum (IVCD) internal antero-posterior (AP) diameters of the IVC at the end of expiration and inspiration respectively overone respiratory cycle will be measured using M mode.

IVC Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter - Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

For IJV measurements,a linear ultrasound probe of 13MHz will be placed on the right side of the neck in transverse plane over right internal jugular vein 2 cm above sterno-clavicular joint just lateral to cricoid cartilage.We will prefer right IJV over left IJV as diameters in right IJV are significantly larger than left IJV. Care will be taken not to compress or obliterate the vein by applying minimal pressure.

The transducer will be held perpendicular to the skin and parallel to the cricoid cartilage. The changes in anterior-posterior [AP] diameter of internal jugular vein will be recorded during one respiratory cycle (inhalation and exhalation) and the collapsibility index will be derived using M mode, using the formula:

IJV Collapsibility index (CI) =

$$\frac{\text{Maximum AP diameter-Minimum AP diameter}}{\text{Max AP diameter}} \times 100$$

After the above measurements, another reading of IJV maximum and minimum diameters will be taken with patient's head elevated at 30^0. Co-loading with 500 ml normal saline infusionwill be started in every patient after recording baseline collapsibility indices of IVC and IJVand sub arachnoid block will be performed with patient in sitting position under all aseptic precautions. A 26G Quincke needle will be inserted in the space

between L3 and L4 vertebrae and after obtaining free flow of clear CSF, 10 mg 0.5 % hyperbaric Bupivacaine (2ml) along with 25µg Fentanyl (0.5ml) will be injected intrathecally.

The patient will be shifted to supine position immediately. Patients' non invasive blood pressure and heart rate will be recorded every 1 minute for first ten minutes and then every 2 minutes for next 20 minutes after spinal anaesthesia.Assessment of loss of cold sensation will be done with spirit swab to check the level of sensory block and motor block will be checked by voluntary lifting of legs by the patient using modified Bromage Scaleevery 2 minutestill 30 minutes.Time taken to achieve the highest sensory and motor levels will be recorded.

Bradycardia will be defined as heart rate going below 60 beats per minute and will be treated with IV administration of 0.6mg atropine.

Hypotension will be defined as fall in systolic blood pressure > 30% from the baseline or any episode of systolic pressure going below 90mm of Hg. If hypotension occurs, the patient will be managed by rapid fluid administration and incremental doses of 6mg ephedrine boluses every 3-4 minutes according to the requirement for maintaining the blood pressure within normal range. Concomitant Oxygen administration using venture mask will also be started if patient develops significant bradycardia or hypotension. If hypotension still persists, nor-epinephrine infusion at 3-10µg/kg/min will be started and dose will be appropriately adjusted.

The incidence and severity of fall in blood pressure will be recorded and co-related to baseline Inferior vena cava and Internal jugular vein diameter collapsibility index.

Outcome:

PRIMARY OUTCOME

The study will compare the efficacy of inferior vena cava and internal jugular vein collapsibility index in prediction of hypotension in a patient undergoing spinal anaesthesia.

STATISTICAL ANALYSIS

Study design: Prospective Cross Sectional Study

Sample Size: Sample size calculation for this study is done by the following formula:

Sample size based on sensitivity = $\frac{Z^2 * S_N * (1-S_N)}{L^2 * p}$

Sample size based on specificity = $\frac{Z^2 * S_P * (1-S_P)}{L^2 * (1-p)}$

Where S_N-Sensitivity, S_P- Specificity

p- Incidence rate of hypotension (45%)

L- absolute precision desired on either side of sensitivity and specificity

Z- standard normal deviate corresponding to the specified size of critical region (α)

For IJV[4],
For sensitivity of 64%, the sample size by the above formula is 40
For a specificity of 64%, the sample size calculation is 32

For IVC[5],
For sensitivity of 84%, the sample size by the above formula is 23
For a specificity of 77%, the sample size calculation is 25

Therefore, for the present study, the higher value that is 40 has been taken. So total sample size we will take is 50.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

The study does not require any investigation or intervention other than those routinely done for every surgery

7.4 HAS ETHICAL CLEARENCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Attached alongwith.

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PROFORMA

Sr. No. Date of surgery: MRD. No.

Name: Age and Sex: ASA Grade:

Weight: Height: BMI:

Diagnosis: Proposed Surgery:

Drug allergy:

Relevant History:

Past History:

Relevant Investigations:

General Physical Examination

Pulse rate: SpO_2: NIBP:

Respiratory rate: Auscultation:

Systemic Examination

Cns Examination	
Chest Examination	
CVS Examination	
Other System	

Signature of Candidate **Signature of Supervisor**

PARAMETERS OF STUDY

IVC PARAMETERS:

Maximum diameter:

Minimum diameter:

IVC collapsibility index:

IJV PARAMETERS AT 0^0:

Maximum diameter:

Minimum diameter:

IJV collapsibility index:

IJV PARAMETERS AT 30^0:

Maximum diameter:

Minimum diameter:

IJV collapsibility index:

Highest level of sensory block achieved:

Time taken to achieve highest level of sensory block:

Highest degree of motor block achieved:

Time taken to achieve highest degree of motor block:

Signature of Candidate **Signature of Supervisor**

Time	Heart Rate (bpm)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)	Mean Blood Pressure (mmHg)	Complication	Intervention
Before Spinal						
Baseline						
After Spinal						
0 Minute						
1 Minute						
2 Minute						
3 Minute						
4 Minute						
5 Minute						
6Minute						
7Minute						
8 Minute						
9 Minute						
10 Minute						
12 Minute						
14 Minute						
16 Minute						
18 Minute						
20 Minute						
22 Minute						
24 Minute						
26 Minute						
28 Minute						
30 Minute						

Signature of Candidate

Signature of Supervisor

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o.....am willing to participate in the study **"INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

.....
Signature of the Witness

.....
Signature of the patient

Name:

Signature of Supervisor

Signature of Candidate

मरीज अनुमति फार्म

तिथि _____

मैं _____पत्नी/पुत्र/पुत्री _____ निवासी _____ इस शोधकार्य **"INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION"** में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____

गवाह के हस्ताक्षर

नाम:

_____

रोगी के हस्ताक्षर/अंगूठे का निशान

नाम:

_____

अन्वेषक के हस्ताक्षर

_____

विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____ਵਾਸੀ

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"INFERIOR VENA CAVA COLLAPSIBILITY INDEX VS INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX FOR PREDICTION OF POST SPINAL HYPOTENSION" ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾ ਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

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ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____ ਮਿਤੀ_____

ਪਤਾ _____ ਪਤਾ _____

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ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

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ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ